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COMPLETE SPECIFICATION

Continuous Aseptic Canning Process and Apparatus

I, WILLIAM MCKINLEY MARTIN, a citizen of the United States of America, of 457 Virginia Avenue, San Mateo, California, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a continuous heating method and apparatus for sterilising liquids and flowable liquids containing solid particles for use in aseptic canning systems and in other food and chemical processing systems. It relates especially to the aseptic canning of foods containing suspended solids, for example such foods as vegetable soup, beef stew, and the like. The invention comprises a substantially complete process in which presized solid pieces of food are blanched and fed in metered amounts into a liquid phase of the food product and are mixed with it. Short-time, high temperature sterilisation is employed in a novel manner. The sterilised food is then cooled and dispensed into cans by a novel filler. The invention includes unusual coaction between several different parts of the complete system and also incorporates novel features in many of the elements themselves, including an improved method and improved apparatus for metering and blanching sizable particles of food; and an improved apparatus for mixing the solid components with metered amounts of a liquid foodstuff.

The present invention has the aim of preventing disintegration, attrition, or mushing of the solid components in the food product while assuring their complete sterilisation, and their accurate and rapid filling into the presterilised containers. It also enables the continuous production of canned fluid or semi-fluid food products containing solid pieces and having better flavour, colour, texture, and uniformity than are produced by some known canning methods. The invention can also be used to produce homogeneous liquid and semi-liquid canned products of improved quality.

According to the invention the continuous aseptic canning process for a product consisting of food containing large particles, comprises continuously pumping a said food; spreading said pumped food into a moving film; contacting, without intermixture, the surface only of said film with superheated steam under pressure sufficient to prevent its condensation so as to raise the temperature thereof in the range of 275° F. to 300° F. while maintaining all other surfaces of said film in contact with cooler temperature bodies; sterilising said food at said temperature; cooling said food below its flash temperature at atmospheric pressure; and measuring said food and dispensing it under sterile conditions at atmospheric pressure into sterile containers while holding the back pressure between said contacting step and said measuring step at the point of said measuring step.

The invention also includes an apparatus for carrying out the process comprising the combination of metering means for both solid and liquid components of the food, mixing and feeding means, a product heater having a supporting surface for distributing a product to be heated over the surface in a thin, gently-moving stream, means for continuously pumping the food, means for continuously contacting the surface only of the stream with hot gas, means for keeping the supporting surface at all places cooler than the product in contact with it, and a closed housing having a product inlet, a product outlet near the bottom of the housing, pumping means for pumping the mixture of the

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liquid and solid food to the heating means inlet, a filler having means for aseptically dispensing the mixture into sterile containers, and conduit means for connecting the filler to the outlet from the heating means, the conduit means having flow-responsive means therein that responds to the dispensing rate of the filler, means responsive to the flow-responsive means for controlling the rate at which the pumping means operates, means for sterilising food containing large particles at a temperature in the range of 275° F. to 300° F. and under sufficient pressure to prevent flashing of the food, means for cooling the food below its flash temperature at atmospheric pressure, means for measuring and dispensing the food at atmospheric pressure, and means for holding the back pressure between the contacting step and the measuring step at the point of the measuring step.

The continuous aseptic canning process differs from some known canning methods, in that the product to be canned is heated and sterilised in the manner described and claimed in our co-pending application No. 17901/62 (Serial No. 978806) before it is sealed in the containers, or even put into them. Application No. 17901/62 (Serial No. 978806) claims a method of heating and sterilising a fluid foodstuff prior to its packaging and in continuous flow in which the foodstuff is flowed over and in contact with a heat-exchanger surface and in a thin moving body, the exposed surface of the body of food being in direct contact with a rapidly moving body of hot gas without intermixture of the food and the gas while maintaining all other surfaces of the foodstuff in contact with bodies at a cooler temperature.

Application No. 17901/62 (Serial No. 978808) also claims a fluid foodstuff heater including a supporting surface, means for distributing the foodstuff to be heated over said surface in a thin, gently-moving stream, means for providing a rapidly moving stream or body of hot gas, means for continuously contacting the surface only of said stream with said hot gas and means for keeping said supporting surface at all places cooler than the foodstuff in contact with it.

In the conventional methods, the product is first put into the containers and sealed, and then the sealed containers are heated in a pressure cooker or retort to sterilise the product. In aseptic canning, the product is quickly heated to an elevated temperature in the range of 275—300° F., is maintained at that temperature for sufficient time to effect sterilisation, and is then rapidly cooled to 90—110° F.; the cooled sterile product is filled into presterilised containers in a sterile atmosphere, and the containers are sealed with sterile covers, while still in the sterile atmosphere.

The heat-treatment received by the product in the sterilisation step of the aseptic canning method is a matter of seconds, as compared with minutes in the conventional canning methods. For example, the conventional in-can sterilisation process for green split pea soup in 303 × 406 cans (16 oz. size) comprises heating the sealed can of soup for 55 minutes at a temperature of 250° F. In comparison, the aseptic canning method achieves sterilisation of the same product before filling, by holding it for only 8.8 seconds at 286° F. In the process of this invention, it takes only one or two seconds to heat the soup to 286° F., for a total heating time of about ten or eleven seconds to effect sterilisation.

While the short-time, high-temperature sterilisation process of this invention lends itself to continuous high-speed aseptic canning with more precise automatic control and consequent savings in labour and heat-energy, these savings and this speed are not its only advantages. The finished canned product may have better flavour, colour, texture and vitamin content than the product resulting from lower temperature and slower sterilisation.

This outstanding improvement in quality is due to the fact that the lethal effect of heat upon bacterial spores increases at a very much higher exponential rate with increasing temperature than do the chemical changes that cause the degradation of flavour, colour, texture and vitamin constituents of the product. In fact, the sterilising effect or lethality, time being constant, increases tenfold while the chemical reactions responsible for degradation of food quality increase only twofold, with each increase in 18° F. in process temperature. Some idea of the importance of this interesting relationship can be grasped by remembering that $2^4=16$, whilst $10^4=10{,}000$.

There are, however, many difficulties involved in quickly heating food products to temperatures of 275—300° F. Scorching and local overheating of the product at the heat-exchange surfaces in the heater are difficult to avoid—almost impossible when using most conventional heaters. Also, the solid components of the product tend to be disintegrated or mushed by their movement through the heater and other parts of conventional processing equipment.

Food products, being of organic composition, are very heat sensitive; they readily adhere to, and form crusts or films on, the hot surfaces of the types of heat-exchangers heretofore known. Local overheating or scorching of solid material which adheres to the heat-exchange surface not only imparts a cooked or burnt flavour and an objectionable colour to other parts of the product contacting it in movement through the heater; in addition, burnt-on or heat-con-

gealed film on the heat-exchange surface markedly reduces the efficiency of heat-transfer.

If the product to be processed contains suspended solids of a frangible nature, the problems of heating and handling through the processing equipment are even more difficult.

The present invention avoids mechanical damage and disintegration of solid components of foods by gently flowing the liquid-solid food mixture in a quiescent state and in a relatively thin layer with only its free surface in contact with superheated steam, which sweeps the surface at high velocity. The food being heated and the steam are thus maintained as two separate and distinct phases without inter-mixing. The gently moving quiescent food mixture is quickly heated, while violent agitation and the consequent disintegration of solid components are avoided. Thereby a product of fluid nature may be efficiently heated to any desired temperature in the required range without scorching, product burn-on, or incrustation on any heat-exchange surface. The heat-exchange takes place between a hot gaseous or vapourous heat-exchange medium in the turbulent state and a gently flowing, cooler, product, thereby avoiding inefficient insulating layers which would be present in case of laminar flow contact. The invention enables controlled dilution or concentration.

High-temperature sterilisation cannot be done after the product has been put in the can because of the slow rate of heat transfer from the outside to the interior of the product and because of control difficulties. The volumes and cross-sectional areas in cans are so large that when a peripheral portion is heated to 300° F., the inside centre remains below the sterilisation temperature long after sterilisation has been completed at the peripheral portion and after prolonged heating has already begun degradation of the peripheral portion.

With viscous products in which heat-transfer is by conduction and not by convection, high processing temperatures can not be used after the product is in the can because of excessive scorching of the product in contact with the excessively hot can walls. Furthermore, even with non-viscous or low-viscosity liquid products, as well as particulate-type products such as whole kernel corn in brine and peas in brine, in which the heat-transfer is largely by convection, high temperature processes can not be used satisfactorily after the product is in the can, because of the difficulties of accurately controlling the short process times required in the high-temperature ranges. Another difficulty is that the head-space or fill of the can affects the degree of agitation of the product in the can, and if the can is overfilled, the reduction in head-space is reflected in less effective heat-transfer, consequently, there is danger of under-sterilisation with a consequent hazard of spoilage of the finished canned product.

In this invention, the high-temperature sterilisation step precedes the filling step. The product is spread out in a thin layer and quickly brought to the sterilisation temperature. Subsequently, the sterile food is cooled and is filled and sealed in the cans at the relatively cool temperature of about 90—110° F. That means that the already-sterilised food has to be put into already-sterile cans and sealed by already-sterile covers. It also means that the sterility of the cans and food must be maintained and protected before, during, and after the filling operation.

The filling machine provided by this invention can be conveniently operated under completely sterile conditions. This filling machine is described and claimed in our co-pending Application No. 19312/63 (Serial No. 978808) which claims a filler for an aseptic canning system for foodstuffs, having an inlet manifold, a plurality of measuring cylinders, each with a reciprocating piston and off-on inlet means and off-on outlet means adjacent one end, means for cyclically and sequentially (1) closing each inlet means when its associated piston reaches the inner limit of its stroke, (2) opening each outlet means immediately after closure of its associated inlet means to dispense the foodstuff, (3) closing each outlet means at the outer limit of the stroke of its associated piston, and (4) opening each inlet means, conduit means for connecting the cylinder inlet means of all the cylinders at all times to the manifold, means for sterilising each cylinder on each side of its piston and for sterilising all the off-on means, means for introducing sterile fluid on the opposite side of each piston from the off-on means at all times to maintain each cylinder in a sterile condition, means enclosing each outlet means in a filling enclosure, and means for maintaining the enclosure in a sterile condition.

Fillers already on the market can accomplish that object for *some* foods, but none of them has been suited to what I call "particulate foods", i.e., foods containing actual pieces of solid food material. For example, vegetable soup may contain whole peas and beans, diced potatoes, carrots, and pieces of celery. Beef stew would contain chunks of beef, diced potatoes and carrots, and so on. Filling machines capable of aseptically canning non-particulate liquid products have been unable to accommodate such gross pieces without chewing or pulping them into a practically homogenised slurry. Friction between the food and the edges of the machine or even friction between the food particles have worn down the particles by attrition. Moreover, in

some machines, the valves have been rendered inoperative or even damaged by the accumulation of such particles; in other machines the particles have been broken up, mashed and destroyed as individual particles by the valves. Since we eat with our eyes and by feel as much as with our palate, such foods are not acceptable and nullify a basic object of aseptic canning—which is to distribute to consumers canned food substantially identical to what a good chef or cook would serve directly from his kitchen.

The invention solves the problem of providing a filler capable of use with particulate foods without damage to the solid components and without adversely affecting operation of the filler.

Sterilisation and cooking at temperatures higher than 212° F. can be carried on only at high pressures. For example, at 290° F. the pressure has to be maintained at not less than about 43 p.s.i.g., which corresponds to the vapour pressure of water at that temperature; otherwise the water content of the product will flash. Flashing cools the product, dropping it back to the temperature at which water vaporises under the prevailing pressure. Flashing also tends to disintegrate the solid food particles; for example, if peas were being cooked under pressure at 290° F. and the pressure suddenly dropped, the peas would explode due to the sudden exit of steam from within the peas. Flashing also affects the flow of a continuous process by its effect upon the products in the process.

Therefore, in an aseptic canning process, it is very important to maintain back-pressure on the product stream. Ahead of the filler, the food is heated in a continuous stream to the sterilisation temperature; then it is held at that temperature, while moving under pressure; next it is cooled to the desired filling temperature, while still moving and still under pressure,—all this in order to maintain the back-pressure in the heating and holding portions of the system. It is therefore necessary to maintain the product under pressure until it is finally discharged from the filler. Accordingly, it is important that the filler operate at pressures not lower than this back-pressure and that the filler not cause this back-pressure to fluctuate any substantial amount. It is also important that the filler itself be accurate and not be affected adversely by the pressure of the product stream and that the product not be affected adversely by the filler.

Fillers currently in use for aseptic canning of homogeneous liquids employ a metering pump just ahead of the filler in order to maintain this back-pressure. However, when handling foods containing solid pieces, such as vegetable soup, such pumps give rise to three serious objections:

(1) The pump chops and disintegrates solid components and thus gives the finished product an unattractive mushed or mulligan-like appearance.

(2) Slippage of the liquid phase of the product under pressure through clearances in the pump results in straining out solid components in the pulsating or intermittent metering operation of the pump, with a consequent accumulation of the solid components in the line *ahead* of the pump. The solids thus accumulated in the line ahead of the pump are discharged with each cycle of the pump. If the liquid phase of the product is thin or of low viscosity, the slippage of the liquid through the pump will be so great that the speed of the pump will have to be greatly reduced in order to maintain the flow to the filler at a constant rate.

(3) Metering pumps capable of handling liquid-solid mixtures without attrition of the solids can not be used in maintaining back-pressure in the system during presterilisation of the equipment, because of the slippage through the pump. Even when the pump is standing still, slippage is such that steam pressure in the heating unit would have to be reduced below that necessary to maintain the temperature required to sterilise the system. Moreover, there would be flashing of the superheated water in the discharge side of the pump with a resulting reduction in temperature below that necessary for sterilisation of parts of the pump and the system beyond the pump through the filler.

The filler of the present invention maintains the back-pressure in the product stream at all times in its operation, without causing fluctuation during any portion of the filling cycle, and, moreover, the pressure level of the product stream does not adversely affect the filler or its operation. In contrast, none of the known fillers are capable of maintaining back-pressure.

When aseptically canning a mixture comprising a liquid phase and a solid phase, special problems arise. One of these is the difficulty of maintaining a set proportion of liquids to solids all through the process. Obviously, no canning process can be satisfactory which results in filling some cans with more liquid and less solid than other cans. Usually, there are several solid ingredients, as for example potatoes, peas, celery, carrots, and beef may all be added in chunks to the same soup. There is, then, also the problem of maintaining the correct relative proportions among these ingredients. To add all the solid ingredients to the liquid ingredients and then stir them by mechanical mixers is likely to result both in poor proportioning and in crushing, mangling or otherwise damaging some of the solid components.

Also, it is conventional to blanch solid ingredients before putting them into the liquid mix, and this has to be done in a way

that will not result in either overcooking or underblanching.

The solution of these problems is among the objects of the present invention.

Other objects and advantages of the invention will appear from the following description of a preferred embodiment, and of some modifications.

The present invention embodies pumping the mixture into and through a product heater, and quickly heating the product mixture to temperatures in the range of 275—399° F. without local overheating or scorching of any parts of the product and without attrition or disintegration of the solid components.

In the accompanying drawings:

Figs. 1A and 1B comprise a two-part isometric and partly diagrammatic view of an aseptic canning apparatus embodying the principles of the invention. Some parts are broken away and shown in section, to disclose other parts. Fig. 1A shows the metering and mixing apparatus and the product-sterilising heater, while Fig. 1B shows the temperature-maintaining and cooling apparatus, the container steriliser, the filler and the container-closing apparatus.

Fig. 2 is an enlarged view in elevation and partly in section of the apparatus for metering the liquid component of the food to be canned, for metering and blanching the solid components, for mixing them together and pumping them through the remainder of the system. Some parts are broken off or broken apart to conserve space;

Fig. 2A is a fragmentary enlarged view in elevation and in section of the butterfly valve, taken along the line 2A—2A in Fig. 2;

Fig. 3 is a further enlarged view in elevation and partly in section taken along the line 3—3 in Fig. 2;

Fig. 4 is a view in elevation and in section on the scale of Fig. 3 of a portion of the solids-metering and blanching apparatus of Fig. 2;

Fig. 5 is a still further enlarged fragmentary view in elevation and in section, taken along the line 5—5 in Fig. 2;

Fig. 6 is a fragmentary view in elevation and in section of an end portion of the feed screw used in the solids-metering and blanching apparatus;

Fig. 7 is a view in elevation and in section of a pump suitable for use in this invention;

Fig. 8 is a view in elevation and in section, enlarged with respect to Fig. 1A, of a food-heating steriliser apparatus embodying the principles of this invention. Some of the piping and valves are shown diagrammatically, and some associated elements are shown, partly in elevation and partly broken away and in section;

Fig. 9 is a view in horizontal section, taken along the line 9—9 in Fig. 8;

Fig. 10 is an enlarged view in horizontal section taken along the line 10—10 in Fig. 8;

Fig. 11 is a view in elevation and in section of a portion of a modified form of anti-bridging device that may be used in the float chamber of Fig. 8 or in the mixing device of Fig 2. Fig. 11 is on an enlarged scale with respect to Fig. 8;

Fig. 12 is a view in elevation of a filler embodying the principles of the invention. Some parts have been omitted, some parts have been broken off, and some parts have been broken away and shown in section along the line 12—12 in Fig. 13 to reveal parts behind them more clearly;

Fig. 13 is a top plan view of the device of Fig. 12, partly broken away and shown in section omitting some parts that would tend to obscure the view;

Fig. 14 is a view in horizontal section taken along the line 14—14 in Fig. 12;

Fig. 15 is a condensed developmental view in elevation corresponding to the path shown in the circle 15—15 in Fig. 13 and illustrating the filling cycle together with the valve-operating cam arrangement;

Fig. 16 is an enlarged view in elevation taken along the line 16—16 in Fig. 13, showing one of the ends of the product-filling cylinder and its valves;

Fig. 17 is a vertical sectional view on the scale of Fig. 16 taken along the line 17—17 in Fig. 13.

General Outline of the Aseptic Canning System of the Invention (Figs. 1A and 1B)

A liquid-supply unit A (Fig. 1A) feeds the liquid phase of a product to be scanned to a liquid-metering unit B. Meanwhile, a solids supply, metering, and blanching unit C feeds various measured amounts of particulate or solid components into a mixing device D, where the solids are added to and mixed with the liquid. From there, the mixture is forced by a pump E through the remainder of the system, going first to a product-heating unit F and then into a flow-control device G. The flow-control device G regulates a variable speed motor H, which in turn controls the speed of the pump E and the metering rate of the solids-feeding unit C.

From the flow-control device G the hot mixture passes through a high-temperature-maintaining device I (Fig. 1B), where sterilisation is completed, and then flows through a cooling means J. The cool sterilised product then flows to a filler K. A container steriliser L supplies empty sterile containers M to the filler K, and filled containers N pass from the filler K through a sterile conveyor O to a closing machine P. A cover steriliser Q supplies sterile covers to the closing

machine P, which applies them to and seals them on the containers N. The sealed, filled containers R then leave the sterile closing machine P, and a conveyor S takes them outside the sterile atmosphere of the aseptic canner to non-sterile equipment such as the washer, labeller, case packer, and other equipment not directly concerned with the aseptic canning system.

THE LIQUID SUPPLY UNIT A (FIG. 1A)

The liquid supply unit A of Fig. 1A comprises a steam-jacketed kettle 30 containing a liquid food component 31. An outlet 32 at the lower end of the kettle 30 leads into a vertical pipe 33, for gravity supply is desirable in the steps preceding the pump E. However, a pump with a recirculating bypass, may be used if desired. The vertical pipe 33 preferably leads through a three-way valve 34 to a pipe 35. The three-way valve 34 is used during the presterilisation of the aseptic canning system, at which time the valve 34 closes off the pipe 33 from the pipe 35 and connects the pipe 35 to a water pipe 36. The purpose and operation of this feature and a preferred valve structure (Figs. 33 and 34) will be explained later. The pipe 35 leads into the liquid metering unit B.

THE LIQUID-METERING UNIT B (FIG. 2)

The liquid-metering unit B includes a generally cylindrical housing 40 providing a float chamber 41 in which is mounted a float 42. The chamber 41 has a bottom inlet 43 connected to the pipe 35 and also has a radial outlet 44 part way up one side, lower than the desired level of the liquid 31 in the chamber 41. From the outlet 44 a generally horizontal conduit 45 leads into the mixing device D. The liquid 31 has substantially the same level in both the chamber 41 and the mixing device D. The float chamber 41 is of sufficient capacity to give an even flow of liquid through it. In a typical apparatus the chamber 41 may be 10" in diameter and the float 7" in diameter.

The float 42 is provided with a diametral tube, 46 having an extension 47, which enables the float 42 to be slidably mounted on a rod 48. A thumb screw 49 makes it possible to fasten the float 42 at any desired height on the rod 48. The housing 40 has a cover 50 with an oversize, bossed axial opening 51, that serves as a guide for the rod 48, 47. There is plenty of clearance between the tube extension 47 and the opening 51, to enable the escape of any entrained air, and air can also escape from the mixing device D, which is open to the air, for in neither is pressure allowed to build up.

The lower end of the rod 48 is pivotally attached to a linkage arm 52, on the lower end of which is mounted a thin, round butterfly valve 54 in the inlet. The butterfly valve 54, being hydrostatically balanced is easily actuated by the float 42 at all liquid levels in the kettle 30 and at all liquid pressures in the pipe 35.

To facilitate easy and thorough cleaning, the butterfly valve 54 is preferably made in the sanitary design illustrated in Fig. 2A. The valve 54, a thin metal disc, is mounted between the two bearings 55, which are exactly 180° apart. The bearings 55 are held in position in rounded notches 57 in a sleeve 58. The valve 54 can be readily removed, after removal of the cover 50 and float 42, by releasing a clamp 59 and sliding the sleeve 58 out from the housing 40, along with the rod 47 and the linkages 52 and 53.

As the float 42 rises, it moves the linkages 52 and 53 to close the butterfly valve 54 and thereby to reduce the flow of liquid 31. When the float 42 reaches a certain height, the butterfly valve 54 practically closes off the supply of liquid 31. When the liquid level drops, the float 42 opens the valve 54. The float valve 42 thus metres the flow of the liquid 31 from the kettle 30 to the mixing device D and the pump E; it prevents the mixing device D from either overflowing or running empty and assures a level that enables good mixing of the liquid with the solids coming from the unit C.

SOLIDS SUPPLY, METERING AND BLANCHING UNIT C (FIGS 1A AND 2—6)

The metering and blanching unit C for solids includes a series of hoppers 60, one for each solid ingredient, a metering and blanching device 61 at the lower end of each hopper 60, and a single conveyor belt 62 on which all the metering devices 61 mete out their ingredients and which carries them to and dumps them into the mixing device D.

The solid constituents to be measured out may be such things as cubed or sliced vegetables (e.g., potatoes, celery, carrots, onions), and meat (e.g., cubed beef or slices of ham), the cubes may be about 3/8" or 1/2" on a side, or whatever size one wishes them, the cutting being done in any desired manner. If desired, any of these ingredients may be precooked or sauteed. Once prepared, the solid constituents are placed into their respective hoppers 60.

The hoppers 60 are substantially identical in design and operation with such variations as are desirable to accommodate different products. As shown, each hopper 60 has a sloping wall 63 and an open lower end 64 which opens into a hopper-like housing portion 65 of the metering device 60. At the bottom of each metering device 60 is a preferably hollow screw 66 which is rotated so as to move the material out of the housing portion 65 and through and along a trough 67 to an outlet 68. The trough 67 is preferably semi-circular in cross-section with its

sides extending a substantial distance above the hollow screw 66 and both its sides and bottom spaced from the screw 66 enough to protect the solid components from damage. The speed of the screw 66 determines the rate at which the food particles are dispensed onto the belts 62 through the opening 68 in the outer end of the trough 67. To enable blanching the trough 67 is preferably tilted so that the screw 66 has to carry the material upwardly out of the housing 65. Each hollow screw 66 has a stub shaft 69 at its outer end, supported in suitable bearings (See Fig. 6).

The hopper 60 is preferably equipped with a vibrator 70 of any suitable type; mechanical, electrical, or pneumatic. The vibrator 70 prevents the solid constituents from sticking to the sloping walls 63 of the hopper 60, which rests on a frame 71 through flexible or rubber supports 72, with its lower end 64 free to move.

Mounted immediately above the screw 66 in the housing 65 is a shaft 73 on which are mounted a series of curved rods 74. These rods are curved in an arc presenting a convex surface to their direction of rotation with the shaft, whereby particles easily slide off the rods. The ends of the rods or fingers 74 preferably extend as close as possible to the housing and hopper walls, while still clearing them. On a one-foot shaft 73, three or four rods 74 spaced apart and set at different rotative positions on the shaft 73 are sufficient, and too many are undesirable, acting like a paddle. When the shaft 73 is rotated, the rods 74 revolve and prevent the product from caking or lodging and from bridging over the lower end 64 of the hopper 60. Preferably, the shaft 73 is rotated slightly slower, and at least no faster, than the screw 66. This may be done by driving it through a reduction gear 75 and chain 76 from a drive shaft 77 that drives the screw 66. Although the vibration of the sloping hoppers 60 is sufficient to cause most materials to flow freely into the metering device 51, some foods tend to stick together if compressed; without the revolving rods 74, the hollow rotating metering screw 66 would tend to entrude such foods in work-like chunks rather than in individual pieces.

All the metering screws 66 are preferably driven by the same variable-speed motor H which drives the input pump E, all the screws 66 preferably being driven from the same main drive shaft 80. The speed at which the shaft 80 turns determines the rate at which the material is fed to the belt 62. In addition, each screw 66 has a separate variable transmission unit 81, with a calibrated control knob 81*a* for varying its individual speed. This makes it possible to adjust the metering rates of the various screws 66 relative to each other individually while at the same time driving all of them from the same motor H, whose speed is itself regulated in a manner to be explained later.

The conveyor belt 62 is preferably driven at a fairly high speed, so that the solid food components from the various metering units 61 are discharged in a continuous stream into the mixing device D. If the belt 62 moved too slowly, the solid components would build up and be discharged unevenly into the device D. Hence, the belt 62 moves faster than the material can be piled up on it; how much faster is not critical.

As stated earlier, the food solids are blanched or preheated as they move through the metering unit 61. For this purpose, the trough 67 in which the screw 66 moves is tilted upwardly toward its outlet 68. The amount of tilt may be adjusted by supporting the trough 67 in suitable bearings 78 on the shaft 80 and by providing an adjusting screw 79 between the trough 67 and the frame. If adjustment is not desired, a permanent tilt can be provided. Saturated steam or hot water or hot solutions of suitable composition may be used to provide the blanching heat. For this purpose, steam may be supplied by a tube 82 secured to the bottom of the trough 67, and pass into the trough 67 through openings 83. As the steam condenses in the unit 61, a hot water bath 84 may be provided, or, for a steam blanch, all the water may be drained out as it condenses through a bottom outlet 85. If desired, hot water or blanch solution may be directly added from a pipe 86 through nozzles 87 (Fig. 4), and when water or solution is used a higher outlet 88 carries off the excess above a predetermined level, a valve 89 then closing the bottom outlet 85. The blanching time used depends upon the temperature of the blanching agent, the length of the trough 67 and the speed of the screw 66. Since the temperature is never higher than 212° F., blanching time is usually not too critical, unless it lasts so long that it overcooks the food.

THE MIXING DEVICE D (FIGS. 1A AND 2)

The mixing device D comprises a funnel or housing 90 having a side inlet 91 connected to the conduit 45, an open upper end 92, and a bottom outlet 93, which preferably is also the inlet to the input pump E. Solid material falls from the belt 62 directly or down a chute 94 which ends below the open top 92 of the funnel 90, and liquid passes through the conduit 45 into the funnel 90. The liquid flow rate and its level are determined by the float 42, while the solid components falling from the belt 62 are metered by the unit C. A hollow screw 97 mixes the ingredients.

The device D not only performs the function of mixing the solid components with

the liquid 31 as the liquid flows continuously into the input pump E, but performs the very much more important function of preventing the solid components from accumulating and bridging over the funnel outlet and pump inlet 93. Actually, the mechanical operation of mixing the solid components with the liquid is simple compared with the anti-bridging function of this apparatus.

An axial vertical shaft 94 is provided together with driving means 96, which may be, as shown, connected to the motor H, to rotate it at about 40—60 r.p.m. Too fast a speed tends to disintegrate the solids while too slow a speed provides neither adequate mixing nor adequate disbridging. On the shaft 95 is mounted a preferably hollow screw 97 having a descending helical thread terminating in a vertically downwardly extending, radially offset tip 98. This vertically depending tip 98 is an important element of the invention, for without it solid constituents such as cubed potatoes, carrots, beef, and the like soon bridge over the small outlet 93, which is also the pump inlet, and build up a pad or mat of solid constituents. The liquid would be sucked or drawn through the solids, and there would be no distribution of the solids. The solids would continue to build up until they overflowed the funnel 90.

The offset tip 98 of the hollow screw 97 revolves in a circle around and close to the inside wall of the inlet 93 to the pump E. The tip 98 is slender and tapered so as to leave as much free space as possible for the converging flow of solids and liquid into the pump E. The circular movement of the tip 98 around and close to the inside wall of the inlet 93 effectively dislodges the solid components which tend to bridge and close the inlet 93. If the tip 98 lay along the axis of the screw 97 and were concentric with the pump inlet 93, it would not dislodge bridged solid components; in fact, it would actually aggravate this problem, because it would leave an annular opening with the rod tip as an obstruction in the centre instead of a free round opening. The tip 98 need not necessarily extend inside the opening 93, except for mechanical guidance. It must, however, be positioned sufficiently close to the inlet rim of the opening 93 to dislodge any bridged solid components. For practical mechanical reasons, the tip 98 preferably extends about 1/4″ inside the inlet 93.

Although circular motion of the tip 98 is preferable, oscillatory motion in a plane or arc has been used quite successfully. In fact, an oscillating or rapidly swinging 1/8″ diameter stainless steel rod 99 (see Fig. 11) with a tip 98 has been used to prevent bridging of solids at the pump inlet 93.

Referring to Fig. 2, it will be seen that the open screw 97 is of steep pitch and of such dimensions that there is ample space for free flow of solids and liquid irrespective of the movement of the screw 97. This construction is used in order not to compress or compact the solid components. The hollow screw 97 provides a larger opening, more free space, for the free flow or movement of the mixture and damages the solids less than would a solid screw. The open screw 97 thus functions more as a revolving spiral stirrer than as an actual conveyor screw. A spiral rod with tapered tip may be used, if desired, in place of the screw 97, though the flattened screw is more effective in stirring and mixing the solid components into the liquid and tends to urge or gently impel the mixture downward into the pump without damaging the solid components. Thus, the open screw 97 gently stirs the mixture while at the same time impelling it downward into the inlet 93 of the pump E, where its slender tapered tip 98 moves in a circle and prevents bridging of solid components, as already explained.

The liquid level in the mixing funnel 90 is maintained only high enough to facilitate effective mixing of the solids with the liquid. If the level is too high above the conduit 45, the larger volume of liquid will not be as effectively stirred by the revolving screw 97. The solid components would not, in this case, be as evenly mixed with the liquid flowing through the bottom part of the mixing funnel 90. If, on the other hand, the level of liquid in the mixing funnel 90 were maintained at too low a level, there would be danger of air being drawn into the pump E along with the product mixture. The proper level has been found to be slightly above the conduit 45.

The Input Pump E (Figs. 1A, 2, and 7)

The input pump E is a suitable type of positive-displacement pump driven by a variable-speed motor H. It should be capable of pumping liquid products at pressures up to about 80 to 100 pounds per square inch and capable of operation without chopping or mechanically disintegrating the relatively soft food solids. It is a valveless pump, for valves tend to crush, cut, or chop the product. One such pump is shown in Fig. 7. The pump E is preferably of the type having a pair of twin-lobed impellers 101 and 102 and an outlet 103 or a single lobe impeller.

The pump E feeds the mixture 104 into the pipe 105 and on through the system to the point where the filler K dispenses the mixture 104 into the containers M. There are no valves or other obstructions between the pump E and the filler J, though there is the flow-control device G beyond the heater F.

The Product Steriliser-Heater F (Figs. 1A, 8 and 9)

The heater F includes an insulated housing 110 having a cylindrical upper portion

111 with a closed upper end 112, a central cylindrical portion 113, and a conical funnel-like lower portion 114. The housing 110 may conveniently be made in two flanged pieces held together by eye bolts 119 having a ring 119*a* fitting through the eyes to give even pressure. The lower portion 114 has an outlet tube 115 leading from near its lower end at one side thereof and also has a central axial bottom opening 116. The inlet pipe 105 leads into the opening 116. An inlet tube 117 has its lower end rotatably mounted in this bottom opening 116 with suitable sealing means 118 to prevent leakage of the liquid at that point.

A motor 120 is provided to rotate the inlet tube 117 at a desired speed, preferably around 40 to 60 r.p.m. The inlet tube 117 has a portion 121 extending at an angle up into the housing 110, generally parallel to the conical wall 114. At its upper end, the tube 117 has an outlet spout 122 that always faces the adjacent central cylindrical housing wall 113, closely adjacent the upper end of the lower portion 114. The tube 117 and spout 122 act to pour the product gently down the sloping wall 114 and to distribute it around the housing 110 in a thin film. The slow speed of rotation of the spout 122 does *not* project the product by centrifugal force against the walls. The gently flowing product is heated by surface contact only with a swirling mass of superheated steam.

The housing upper portion 111 is provided with a pair of annular partitions 123 and 124. The lower partition 123 is preferably conical and extends inwardly and downwardly to an inner periphery 125. The upper partition 124 also slopes down and is approximately parallel to the lower partition but is provided with a depending cylindrical portion 126 spaced inwardly from the inner periphery 125 of the lower partition 123. The lower end of the depending cylindrical portion 126 is tapered outwardly and terminates in a generally radially outwardly extending flange 127. The periphery of the flange 127 is approximately in vertical alignment with and approximately at the same radius as the inner periphery 125 of the lower partition 123. Between the upper and lower partitions 123 and 124 the upper housing wall 111 is provided with an inlet opening 128 for superheated steam. A cooling channel 129 is provided for circulating water to keep the adjacent housing wall cool so that spattered soup or other food product being heated will not be burned onto the housing surface. Additional channels like the channel 129 may be provided wherever desired, especially where the housing is shaped differently than the housing 110. For example, there may be one around the wall 113.

Thus the housing 110 is divided by the partitions 123 and 124 into three main chambers, an upper chamber 130, an intermediate chamber 131 where the steam is introduced, and a lower chamber 132 into which the food product 104 is introduced by the revolving spout 122. From the spout 122 the product 104 flows gently onto the vertical wall 113 and down the sloping wall 114, the rotation of the inlet tube 117 serving to spread the product 104 out into a film-like mass 133. The slope of the wall 114 depends upon the viscosity of the material 104 and upon the contact time desired to heat it. For more heating contact, the slope should, of course, be less, and for less viscous material the slope should also be less. A slope of about 45° is satisfactory for many soups, but different slopes may be used, depending on the desired operating conditions including the size of the device as well as the type of product.

The upper end wall 112 of the housing supports a drive shaft 134, which extends down along the axis of the housing and at its lower end supports a fan 135. The drive shaft 134 projects out of the housing 110 and is provided with suitable driving means, such as a high-speed motor 136 acting through a bolt 137 and a sheave 138 on the shaft 134. A suitable thrust bearing 139 is provided to support the shaft 134, and preferably the shaft 134 is protected and sealed by a housing 140, which encloses a cooling tube for water and a lubricating system for the shaft 134.

The fan 135 is a compound structure rotating with the drive shaft 134. It includes a hub 140*a* from which extend a plurality of inner blades 141 which are tilted so that, when they rotate, they move steam from below them to above them. At the outer periphery of the inner blades 141 is a cylindrical shell 142 which, of course, also rotates with the shaft 134. The upper end of the shell 142 fits fairly closely within the cylindrical depending portion 126 of the upper partition 124, with a suitable working clearance. A series of radially outwardly extending rods 143 is supported by the hub 140*a* and supports a circular rim 144. This rim 144 extends vertically to a level up just below the lower partition 123 and just radially beyond the outer periphery of the flange 127. The upper part of the rim 144 is cut and bent to provide a series of impeller blades 145.

The intermediate chamber 131 serves as a steam entrance and distributing chamber with the steam coming in through the inlet 128 and going out along the lower edge 125. The impeller blades 145 rotating at high-speed (e.g., at about 1800 r.p.m. in a housing 110 about 3′ in diameter) pull the steam out from the chamber 131 and impel it in a whirling motion inside the lower chamber 132 and out toward the walls 113 and 114 down which the food product 104 is flowing gently. To

prevent the impeller blades 145 from driving some of the steam back up into the chamber 131 and causing counter currents, a series of stationary vertical baffles 146 is provided, tilted in the opposite direction to which the blades 145 are tilted.

The hot steam (e.g., at 800—1200° F.) whirled out by the blades 145 (see Fig. 9) comes against the descending food product 104 that is flowing gently down the walls 113 and 114 of the lower housing, this gentle flow constantly exposing new surfaces of the product 104. The whirling steam does not enter the feed product but does heat its surface. Then the cooled steam (e.g., at 350—450° F.) is sucked up by the fan's inner blades 141 and pulled through the interior of the cylindrical partition portion 126 into the upper chamber 130.

The whirling blades 145 provide for very efficient heat transfer by the high-velocity flow of the superheated steam and also throw back into the film 133 any droplets or particles of the food product, to prevent them from splashing against any metal surfaces where they might be charred. In this invention the mixture 104 touches only walls that are cooler than the mixture, i.e., the walls are insulated from the steam by the mixture itself.

A tube 147 leads from the chamber 132 to the control device G for maintaining pressure equalisation, as will be explained later.

The upper chamber 130 is provided with a suitable steam exhaust outlet 148 from which a duct 149 conducts most of the steam to a gas-fired superheater 150 (Fig. 1A) for recirculation. The superheater 150 is provided with a gas burner 151 and heat-exchanger tubes 152. A conduit 153 leads from an outlet manifold 154 of the superheater 150 to the inlet 128 of the product heater F. The return steam enters the tubes 152 from an inlet manifold 155. A steam bleed or discharge orifice 156 provides for the discharge of a constant small amount of steam in order to remove air or other undesirable gases from the system, while a steam inlet 157 admits a controlled amount of make-up steam.

Thus, superheated steam is continuously recirculated through the product heater F from the gas-fired superheater 150 by the fan blades 145 and 141. The superheated steam from the superheater 150 is impelled tangentially into the chamber 132 by the revolving impeller blades 145. The superheated steam thus whirled circularly in the chamber 132 sweeps the surface of the product mixture flowing gently down the walls 113 and 114 and quickly heats the continuously flowing product to the desired process temperature. After sweeping the surface of the product and imparting part of its heat to the product, the steam is recirculated by the fan blades 141 through the chamber 130 and the duct 149 to the manifold 155, and thence again through the superheater 150. The steam thus reheated is returned through the duct 153 to the annular chamber 131 from which it is again impelled tangentially into the product heating chamber 132.

Remarks on the Operation of the Product Heater F

A very important feature of the product heater F is that the product is heated solely by superheated steam at an interface between the steam and the food product 104. Both the product and the steam are moving, but the steam is not injected into the product. There is no mixture of the steam with the product. The contact is *solely with the surface* of the product, and that fact distinguishes it from the prior-art attempts to use steam heating, for in them the material was always heated at least partly by mixture.

The superheated steam impinging upon the gently flowing liquid product strikes the product with sufficient force to cause an interchange between the portion of the product that is on the surface and the underlying product, so that most or all portions of the liquid are presented to and contacted by the steam for uniform heat-transfer throughout the entire liquid mass, all without intermixture of steam and product and without violent agitation of the product. Also, since the liquid is in a relatively thin layer, and since the steam is impelled generally uniformly in the chamber, a large liquid-gas interface is presented for optimum heat-exchange.

Note that the heat is applied to the flowing liquid product directly from the superheated steam through a liquid-gas interface, without employing a solid heat-exchange surface. There is no burn-on, for that can result only when a static portion of a liquid product is overheated at a solid heat-exchange surface and adheres to it. In the heat exchanger of the present invention, the product itself insulates the walls 113 and 114 of the annular chamber 132 so that they cannot be raised to a sufficient temperature to cause burn-on congealing of solids on the underlying metal surface. Only at the upper edges of the liquid does steam reach a metal wall 158 contacting the liquid, and here the cooling channel 129 prevents overheating of the metal wall.

The reason for whirling the superheated steam in the product heating chamber 132 is three-fold; (1) to prevent intermixing of the steam and the product, and thus to maintain the steam and the product as two distinct and separate phases in the heating operation; (2) to prevent the product from spattering onto the hot metal surfaces of the heating chamber 132, on which a spattered product would char and then fall into the product

being processed and degrade it, and (3) to prevent entrainment of droplets or particles of the food product in the steam recirculated through the superheater 150.

The prevention of intermixture has been discussed. As to spattering, even the smallest microscopic droplets of product must be prevented from coming into contact with the hot metal surfaces. The whirling superheated steam picks up any droplets of product that even momentarily leave the surface and throws them back into the gently flowing product stream, by centrifugal force.

Of equal importance is the prevention of entrainment of minute droplets or particles of product in the departing steam, where it would burn in the gas-fired superheater and impart a bad taste and smell to the product when the steam is recirculated. For that reason the return flow of steam from the chamber 132 to the gas-fired superheater 150 is from the *centre* of the chamber 132, which is in effect the vortex of the whirling mass of steam. It follows that any microscopic particles of product will be separated from the whirling mass of steam by centrifugal force and not accompany the steam up from the vortex.

The results of extensive tests involving the continuous processing of pea slurry for 8-hour periods with the superheated steam maintained at a temperature in the range of 800—1000° F., showed no burn-on—not even a trace—on the fan surfaces, on the walls of the housing 110, on the ducts 148 and 153, or in the superheater tubes 152.

Another very important feature of the present invention is the means of avoiding burn-on and accumulation of incrusted charred product at the boundary of the liquid product and the hot metal surfaces 158. Since the product and the steam are maintained as seperate and distinct phases, there is necessarily a boundary at which the product meets the hot bare metal surface 158. The surface 158, being bathed with steam, tends to attain approximately the temperature of the steam, whereas the metal surfaces 113 and 114 beneath the product will be at a temperature lower than that of the product 104. The product striking the boundary therefore tends to burn onto the hot metal surface and rapidly accumulates in the form of an incrusted mass which will be charred by hot steam.

The centrifugal effect of the superheated steam keeps the boundary of the product on the surface 158 close to the vertical wall 113. To prevent burn-on, incrustation and charring of the product on the metal surface 158 a stream of cooling water is circulated through the small annular cooling channel 129. The cooling channel 129 serves as a barrier to the conductance of heat from the superheated steam through the metal 158 to the boundary. By dissipating heat from this narrow margin of metal between the boundary of the product and the superheated steam, burn-on and incrustation of the product is entirely prevented. The cooled margin of the metal surface 158 will be wet with steam condensate at all times, and in consequence the troublesome boundary meets a wet surface instead of a hot dry metal surface.

The "cool barrier" can be provided by other structural designs than the channel 129. For example, a large cooling ring may be provided in the same location as the channel 129, through which the product is pumped before entering the distributor tube 117. The product is thus used as the coolant, the cooling channel serving the two-fold purpose of preheating the product and cooling the metal surface at the boundary between the product and the superheated steam.

The distributor tube 117 rotates at a relatively slow speed, preferably about 60 r.p.m. For a normal-diameter (e.g., two to four feet), housing 110, it should not revolve faster than about 80 r.p.m. because higher speeds of rotation have been found to damage and disintegrate tender frangible solid components in the product. Neither should speeds slower than about 30 r.p.m. be used, for to do so would result in discontinuous flow of product down the walls 113 and 114 of the chamber 132. That is, slow revolution of the distributor spout 122 would cause the product 104 to flow down the metal surfaces 113 and 114 in waves between which the surfaces 113 and 114 would drain substantially dry, and consequently the metal surfaces would be heated by direct contact of the superheated steam between cycles of the product distributor. The product distributor 122 should revolve at sufficient speed to keep the metal surfaces 113 and 114 wetted and covered with sufficient product 104 to prevent the underlying metal from being heated directly by the steam. In this way, the metal surfaces 113 and 114 are always kept at a lower temperature than the product 104 flowing in contact with them, and there is no burn-on or congealing of the product on the metal surfaces.

Temperature and Pressure Regulation of the Heater F (Figs. 1A and 8)

The quantity of heat imparted to the steam as it flows through the superheater 150 may be controlled by the temperature of the heated product, as by a temperature sensing element 160 located between the control device G and the temperature-maintaining device I. The temperature sensed by the element 160 is preferably transmitted to a recording temperature controller 161 of any suitable type.

The controller 161 may control the volume of gas-air mixture flowing to the gas burner 151 by means of a compressed air signal.

Compressed air, with its pressure regulated to a constant value by a regulator valve 162, is supplied to the controller 161, and there its pressure is varied in accordance with the temperature sensed by the sensing element 160. The air then passes by a tube 163 to the diaphragm chamber 164 of a diaphragm-actuated butterfly valve 165. Air supplied under pressure, as by a blower (not shown), passes through the valve 165 into a mixing chamber 166, and its pressure acts on a second diaphragm-actuated valve 167 controlling the admission of fuel gas. The valve 167 assures that the quantity of gas admitted from a gas supply line 168 to the mixer 166 will always be in constant proportion to the quantity of air admitted to the mixer 166. A proportioning valve 169 is used to adjust this proportion.

The quantity of the gas-air mixture supplied to the burner 151 is thus controlled to give a constant temperature of the product at the sensing element 160.

Pressure may be controlled similarly. A pressure tube 170 may transmit the pressure inside the chamber 132 to an indicating pressure controller 171. Air under constant pressure determined by a regulator valve 172 enters the controller 171 where its pressure is varied in accordance with changes in the pressure in the tube 170. This signal air then passes through a tube 173 to the diaphragm chamber 174 of a diaphragm-actuated valve 175. The valve 175 admits pressure steam from a suitable source through a conduit 176 and the steam inlet 157 into the conduit 148 leading to the superheater inlet manifold 155.

As noted before, some steam (along with air, etc.) is constantly being bled from the system through the orifice 156; so the pressure in the chamber 132 will drop unless further steam is supplied through the inlet 157. The pressure controller 171 assures that the proper amount of steam will be added to maintain the pressure at exactly the right amount.

The amount of heat imparted to the product 104 flowing continuously through the heater F is determined by a combination of conditions, the most important of which are:

(1) The temperature of the superheated steam in contact with the surface of the product 104.

(2) The surface area of the product 104 in contact with the superheated steam.

(3) The rate of flow of the superheated steam whirled in contact with the surface of the product 104.

(4) The rate of flow of the product 104 through the product heater F.

(5) The depth of the film or layer 133 of the product 104 exposed to the superheated steam while flowing down the walls 113 and 114.

(6) The pressure of the superheated steam in the heater chamber 132.

In the operation of the heater F, unless the pressure of the superheated steam is equal to or in excess of the vapour pressure corresponding to the mean temperature of the product 104 as recorded by the temperature sensing element 160, the product will flash in the control device G and in parts of the temperature-maintaining device I situated above the control device G. The pressure in the heater F is therefore set and maintained by the pressure controller 171 at a predetermined value equal to or in excess of the vapour pressure of the product in the devices G and I.

For example, when the product is to be heated to a temperature of 290° F. as recorded by the sensing element 160 and automatically regulated at this temperature by the temperature controller 161, the pressure controller 171 is set to maintain a pressure of about 50 p.s.i.g. in the heater F and in the control device G. The vapour pressure of the product at a temperature of 290° F. is approximately 43 p.s.i.g. and about 7 p.s.i.g. excess pressure above that value has been found sufficient to prevent the product from flashing. A slight decrease in the temperature of the product 104 flowing past the temperature sensing element 160 causes an increase in heat at the gas burner 151 and a corresponding increase in the temperature of the superheated steam, which will thus bring the temperature of the product 104 up to the desired level.

As the pressure in the heating chamber 132 is decreased and approaches the vapour pressure of the product 104 at the process temperature, the amount of steam condensing in the product 104 decreases. If, for example, the temperature controller 161 is set to maintain the temperature of the product flowing past the sensing element 160 at 290° F. and if the pressure regulator 171 is set to maintain the pressure at 43 p.s.i.g., the air signal transmitted from the temperature controller 161 to the valve 165 will increase the air-gas supply to the burner 151 until the amount of steam condensing in the product 104 is exactly equal to the amount of steam vapourised from the product 104 and discharged continuously through the bleed orifice 156. At this equilibrium point the amount of steam admitted through the make-up steam inlet 157 by the pressure controller 171 will be exactly equal to the amount discharged through the bleed orifice 156.

If the pressure controller 171 should be set for a pressure below that corresponding to the vapour pressure of the product 104, the temperature of which is still maintained at 290° F., no steam would be admitted to the inlet 157 by the pressure controller 171, and the bleed of steam through the orifice 156 would reduce the pressure in the chamber 132, with a resultant flashing of the product 104. The

flashing would cool the product; so the sensing element 160 would call for more heat from the superheater 150 until equilibrium is again reached. The temperature control system thus would automatically operate to supply not only the amount of heat required to heat the product 104 to the process temperature (e.g. 290° F.) but to supply also the amount of steam discharged through the bleed orifice 156. The product 104 would thus be condensed in this type of operation.

The Control Device G (Figs. 1A, 8, 10, and 11)

From the heater F, the food flows through heat-insulated equipment until it reaches the cooling tubes J. The insulation 177 is not in all instances shown in the drawings, for the sake of simplicity. The conduit 115 leads from the heating chamber 132 to the control device G, which has a housing 180 providing a float chamber 181. Depending from the top of the float chamber 181 is a shaft 182, driven by a suitable motor such as the motor 120 and on it is slidably mounted a float 183. At the lower end of the shaft 182 is a hollow screw 184 like the screw 97 in the mixing device D in construction and operating in exactly the same manner and for the same purpose, that is, for assuring the transmission of the mixture of materials and with a tip 98 that prevents bridging of the outlet 185 and crushing, mangling, or injuring the solid particles.

The float 183 is mounted slidably on the shaft 182 but has no other relation to it except that the shaft 182 serves as a guide maintaining the float 183 in proper diametrical alignment. A lever 186 attached to the float 183 operates a needle valve plunger 187 through a link 188 and a crank 189.

The needle valve 187 serves to throttle a constant stream of air under pressure (e.g. 20 p.s.i.g.) from a pneumatic tube 190, and serves as a control for the variable-speed motor H which drives the pump E. As the liquid level in the float chamber 181 rises, a bleed passage 191 that leads to a bleed outlet 192 is opened wider, thereby reducing the pressure of the air in a chamber 193 ahead of the outlet 192. This reduction in pressure effects a reduction in pressure in a tube 194, which, in turn, lowers the pressure in a pneumatic amplifier 195 (see Figs. 1A and 2), which then acts to slow down the speed of the motor H for the pump E and the metering-blanching unit C. Then, the float 42 acts on the butterfly valve 54 to control the liquid level also, so that the liquid is also metered to give the correct proportion of liquid to solids. Thus the different parts of the system act on each other. In this connection, it should be pointed out, the cause of liquid rising in the chamber 181 and raising the float 183 is either that the pump E is feeding material too fast, or that the filler K is dispensing material slower than its normal constant rate. Normally, the level of the liquid in the float chamber 181 is constant.

A calibrated liquid level indicator 178 may also be operated by the float 183 and helps in setting the proper level in the chamber 181. The level of the liquid in the float chamber 181 should always be high enough to prevent escape of steam into the temperature-maintaining device I and cooling device J. It also should not be below the point where the tube 115 enters the chamber 181, so that steam from the chamber 132 cannot circulate through the chamber 181 and pressure-levelling tube 147, disrupting the steam circulation system and causing burn-on on and near the float 183. The level should not rise so high as to back heated product up into the housing 110.

The pressure-equalising tube 147 maintains the pressure in the chamber 181 at the same level as in the chamber 132, so that the level of the float 183 is not affected by pressure differences. The tube 147 is not used to circulate steam; it merely equalises pressure. The steam in the chamber 181 is saturated and at substantially the same temperature as the product 104 in the chamber 181. This arrangement has been found to be effective in keeping the product from burning onto the float 183 and the housing 180.

The Temperature-Maintaining Device I (Fig. 1B)

The fluid passes from the outlet 185 into the temperature-maintaining device I by which it is held at the desired temperature for a time sufficient to complete sterilisation, which may be from a few seconds up to about a minute. The larger the solid particles, the longer the time necessary to assure complete penetration of the particles, by the heat at the holding temperature. For liquids like homogeneous pea soup 8 to 10 seconds at 286° F. is sufficient. For vegetable soup containing 3/8″ cubed vegetables, a holding time of 38 seconds at 290° F. has been found sufficient for complete sterilisation.

The device I may comprise an insulated tube 196 of diameter great enough to prevent damage to solid pieces in the moving product 104 and long enough to give the desided holding time while the product is continuously moved through the tube 196 by the pressure imparted in the heating chamber 132 at a velocity sufficient to maintain the proportions of the mixture without damage to the solid particles. Here, sterilisation is finished.

The Cooling Device J

Next, the liquid passes into the cooling

tube J, which is provided with a water jacket 197 having an inlet valve 198 and an outlet valve 199 which enable the cooling tube to be drained during initial sterilisation. From there the mixture passes through a pipe 200 to the filler K. Just before the liquid reaches the filler K, there is a valve 201 to which is attached a drain conduit 202 with a back-pressure valve 203. Just beyond the valve 201 is a second valve 204 which may be used to admit steam from a conduit 205 during the presterilising of the system.

Container Sterilisation (Fig. 1B)

In the meantime, containers M have been sterilised by a suitable steriliser L, such as is well known in the art. The containers M are then ready to be fed into the filler K through a sterile passageway 206 by a star wheel 207.

Brief General Description of the Filler K (Figs. 1B and 12—14)

In general the filler K shown in the drawings comprises a stationary main frame 210 and a rotating assembly 211 supported by the frame 210 and cooperating therewith to define a chamber 212 inside which sterile conditions are maintained, as by introducing a steady stream of steam from the container steriliser L and the passage 206. Presterilised empty cans M or other suitable containers enter from the container steriliser L via the enclosed sterile passage 206 and the star wheel 207. The star wheel 207 introduces each empty can M into the chamber 212 through an inlet opening 213, and the can M is carried around a stationary track 214 (supported by the frame 210) while at all times being kept in alignment with a dispensing outlet 215 (Fig. 13). The can M travels approximately 270° along the track 214 and is then taken out as a filled can N at an outlet 216 by a star wheel 217 (or by fingers of a feed chain) and sent by the conveyor O to the closing machine P, both of which are also maintained in a sterile atmosphere.

The Filler Frame 210 (Fig. 12 mainly)

The stationary frame 210 may include suitable standards 220 to hold the filler K above the floor level. The standards 220 support a base 221, which supports the remainder of the frame 210, including a central vertical stationary pipe 222 and a series of upright rods 223 spaced around the periphery of the filler K. The base 221 also supports an annular gear housing member 224 with an upwardly extending bearing boss 225. Secured rigidly to the exterior of the boss 225 is a spider 226 that supports an annular rim 227 with a cam track 228, discussed later. The rim 227 also supports the can track 214 on a series of standards 229.

Rotation of the Housing Assembly 211 and the Star Wheels 207 and 217 (Figs. 12—14)

The rotating assembly or turret 211 includes an upper hub 230 secured to a rotating vertically mounted hollow shaft 231 that is mounted rotatably around the pipe 222. Suitable bearings and fluid seals may be provided along the shaft 231, and the shaft 231 is provided near its lower end with a bevel gear 232, preferably enclosed between the gear housing 224 and the base 221. The gear 232 may be driven by a bevel gear 233 on a drive shaft 234 that lies at right angles to the shaft 231 and is driven by a suitable motor 235, which is the same motor that drives the closing machine P. Thus, rotation of the drive shaft 234 causes rotation of the assembly 211. The drive shaft 234 may also drive the star wheel 207 through gears 236 and 237 and star-wheel shaft 238. Similarly, the star wheel 217 may also be driven from the shaft 234.

The hub 230 has a lower sleeve portion 240 pinned to the shaft 231 and has an upper flange 241. Around the sleeve portion 240 is secured a ring 242 that supports a spider 243. At the outer end of the spider 243 is an annular rim 244 provided with openings 245 in which are seated bushings 246. Inside the bushings 246 short shafts 247 are rotatably mounted, to the upper ends of which are secured container-engaging fingers 250 that engage the containers M and move them around the track 214, each centred beneath a filler outlet spout 215.

The fingers 250 pick up the cans M from the star wheel 206 and propel them through the filler K between a stationary guide rail 258 and a moving guide ring 259, while maintaining the cans always in alignment with the outlet spouts 215. The cam 228 causes the fingers 250 to yield and relax only after the outlets 215 are closed and as the full cans N approach the filler track outlet 216.

The hub flange 241 supports the filler outlet spouts 215, so that their synchronisation with the fingers 250 is assured. It also supports a cup-shaped upper housing 254 that is closed by a sealed cover 255, enclosing a sealed chamber 256. The housing 254 and a block 257 on the flange 241 support each of a set of filling cylinders 260.

The Filling Cylinders 260 and their Pistons 270 (Figs. 12 and 13)

The radially mounted cylinders 260, in any suitable number, lie horizontally and symmetrically around a centre 261 of the housing 254, about which the assembly 211 rotates. The radially inner end 262 of each cylinder 260 opens into the chamber 256, in which sterile fluid is normally retained during operation. The radially outer end 263 of each cylinder 260 is closed by the block 257

except for an inlet opening 264 and an outlet opening 265, preferably at the top thereof. The inlet opening 264, which is lower than the outlet opening 265, communicates with an inlet conduit 266 in the block 257 that leads down from above into the inlet 264, while an outlet conduit 267 in the block 257 leads down from the outlet 265 toward the outlet 215.

A piston 270 reciprocates in each cylinder 260. Preferably, the cylinder 260 and piston 270 are both made of high quality stainless steel honed to enable the use of close tolerances and to prevent undue wear. An O-ring 271 near the outer end of the piston 270 is preferably used to prevent leakage between the piston 270 and the cylinder 260.

The radially outer end 274 of the piston 270 is preferably concave to prevent it from mashing solid ingredients. It faces the outer end wall 263 of the cylinder 260 and is moved away from it to measure a charge of food product 104 in the cylinder 260 and then is moved toward it to dispense the charge. For this purpose, each piston 270 is attached to a rod 275 by a pin 276 to provide a freely rotatable connection, and all the rods 275 of all the pistons 270 are rotatably connected to respective crank pins 277 in a crank ring 280.

The crank ring 280 is journalled on a stationary crankshaft 281 which is supported in a position eccentric to the centre 261 of the rotating structure 211. The strokes of the pistons 270 are identical and are equal to twice the eccentricity of the crankshaft 281, which can be adjusted to vary the length of the stroke.

The Product Tube 200 and Manifold 300 (Fig. 12)

The food product to be dispensed from the filler K comes via the tube 200 to a manifold 300, which may be rotatably mounted on the end of the tube 200 by means of an anti-friction bearing 301, leakage being prevented by an O-ring seal 302. The upper end of the manifold 300 may be a fairly simple sleeve-like fitting 303 surrounding the lower end of the tube 200, while a lower end member 304 of the manifold 300 provides a series of outlet openings 305 that each connect with a filler tube 306, each one of which leads to one of the filler cylinders 260. There are, therefore, exactly as many tubes 306 from the manifold 300 as there are cylinders 260. It may be mentioned that all the connections of the various pipes and fittings are preferably made by using clamps 307 of a well-known type which is easy to sterilise and which, once sterilised interiorly, maintains its sterilisation.

The Inlet Valves 310 (Figs. 16 and 17)

Each tube 306 is connected by an elbow 308 to an inlet fitting 309 of an inlet valve 310. The inlet valve 310 is housed in the block 257 and comprises a ball 311 having a through-passage 312 and a control stem 313, which is rotated to turn the ball 311 ninety degrees between an open position and a closed position. The stem 313 extends through a bushing 314, which is provided with one or more O-rings whose sealing action ensures the maintenance of sterility inside the valve 310.

The ball 311 is preferably supported between two horizontal valve seats 316, preferably of polytetrafluoroethylene, against which synthetic rubber O-ring 317 bears. The O-rings 317 serve the twofold purpose of (1) forming a seal between the valve seats 316 and the flat metal surfaces 320, 321, 322, and 323, and (2) exerting pressure on the valve seats 316 so that the spherically concave seat of the valve seats 316 will be sealed against the convex surface of the polished metal ball 311. Between the metal members 320 and 321 and the valve seats 316, clearance is provided. Clearance is also provided between the valve seats 316 and side walls 322 and 323 at each side of the valve seats 316. Therefore, the valve seats and O-rings can slide relative to the metal members 320 and 321 in between the walls 322 and 323 to provide self-alignment of the valve seats 316 with respect to the ball 311. The ball 311 is thus "floating" between the two valve seats 316, which in turn are slidably positioned between two parallel polished metal retaining surfaces; it is not rigidly supported by the actuating stems 313 or any other element.

A passage 318 leads from the outlet side of the ball passage 312 to the cylinder inlet conduit 266. Thus, when the valve 310 is open, the food product 104, which may have a liquid phase carrying solid particles, flows freely from the tube 200 through the manifold 300 and tubes 306, the valve 310 and passage 266, into the cylinder 260. There is no place along the path from the tube 200 into the cylinder 260 where the solid particles would be subjected to undue friction or attrition tending to break them down. There is no place at the valve 310 where they can catch, and no way in which they can affect the operation of the valve 310.

The Outlet Valve 325 (Figs. 16 and 17)

The outlet valve 325 is substantially identical in construction to the valve 310. It is connected by the conduit 267 to the cylinder outlet 265 and by a dispensing passage 326 to the dispensing or outlet opening 215. It has the same type of internal structure as the inlet valve 310 and is rotated by a stem 327

between an open position and a closed position.

OPERATING AND SYNCHRONISING STRUCTURE FOR THE VALVES 310 AND 325 (FIG. 15)

The valves 310 and 325 are opened and closed by the same type of structure. Each inlet valve stem 313 has a generally triangular cam 330 mounted on its outer end and each outlet valve stem 327 has a similar cam 331. Each cam or valve trip lever 330, 331 has sloping or curved cam faces 332 and 333. On a pair of the standards 223 that project up from the base 221 of the main frame 210, are mounted brackets 335 which are adjustable both vertically and rotatably by means of set screws 336. Each bracket 335 supports two shafts 337 on each of which is mounted one of four cam-engaging rollers 340, 341, 342, and 343.

The roller 340 is mounted beyond the empty can inlet 213 to engage the upper cam surface 332 of the inlet valve cam 330 to cause it to rotate the stem 313, thereby moving the inlet valve 310 from an open position to a closed position as the cam 330 passes by the roller 340. Similarly, the roller 341 is mounted nearer the filled can outlet 216 at a lower altitude than the roller 340 to engage the lower cam face 333 of the inlet valve cam 330 and move the inlet valve 310 from its closed position to its open position.

The roller 342 is like the roller 340 and is mounted just beyond the roller 343 to engage the upper cam surface 332 of the cam 331 to move the outlet valve 325 from its closed position to its open position just after the inlet valve 301 is closed. The roller 343 is, like the roller 341, mounted to engage the lower surface 333 of the outlet valve cam 331 to move the outlet valve 325 from its open position to its closed position just before the inlet valve 310 is opened.

Since the shafts 337 for the cam rollers 341 and 343 are stationary during operation of the device, they are adjusted to a proper position for maintaining synchronisation with respect to the stationary crankshaft 281, and this synchronisation, once obtained, remains unchanged regardless of the distance from the crankshaft 281 to the centre 261. The initial adjustment is readily attained by means of the bracket 335.

The bracket 335 for the rollers 340 and 341 is mounted rigidly on a sleeve 344 that is rotatable on the standard 223, so that both the trip rollers 340 and 341 may be swung outwardly to an inoperative position by a no-can no-fill lever 345 that is also rigidly secured to the sleeve 344. The lever 345 is pivotally joined to a link 346, which in turn is pivotally joined to an arcuate arm 347. The arm 347 is positioned just below the guide rail 258 and normally parallel to it and is mounted on a pivot 348. A spring 349 urges the arm 347 toward a position in beyond the guide rail 258. As empty cans M are moved onto the track 214 by the star wheel 207 and are carried around on the track 214 by the finger 250, the lower wall of the cans bears against the arm 347 and swings the lever 345 outwardly to move the bracket 335 inwardly toward the valve trip levers 330 and 331. However, if there is no can beneath an outlet 215, the spring 349 swings the rollers 340 and 341 out of the way where they cannot engage the valve trip levers 330 and 331. Thus, no product is dispensed from the cylinder 260 unless there is a can beneath the outlet 215, and the movement of the piston 260 merely backs the product temporarily up the pipe 306 and to another cylinder, so that no harm is done. Since the inlet valve 310 is kept open, the incompressible fluid cannot break the cylinder 260 or associated parts. If no cans move into the filler K for a while, the float 183 in the control device G regulates the pump E and metering devices B and C in the manner already described.

THE FILLING CYCLE (FIGS. 13—15)

The filling cycle can best be understood with reference to Figs. 13 to 15. Starting at the left of Fig. 15, it will be seen that the outlet valve 325 has just been closed, and the can N has just been filled. The can roller 343, which closed the outlet valve 325, is so located that it engages the cam 331 and closes the outlet valve 325 at the very moment when the piston 270 reaches the outer limit of its stroke. It will be evident that this time is unaffected by the adjustment of the crankshaft 281 toward or away from the centre 261. Also, since the cylinder outlet opening 265 is near the top of the cylinder 260, all the material dispensed through the outlet valve 325 is driven there by the piston 270 instead of being able to run out freely as it would if the cylinder outlet opening 265 were located at the bottom of the cylinder 260. Moreover, by having the outlet opening 265 at the top of the cylinder 260, any air or occluded gas in the product 104 is expelled. If, on the other hand, the outlet 265 were at the bottom, accumulated air or gas would not be expelled, but, being under pressure in the cylinder 260, would expand when the outlet valve 325 is opened and the product 104 would spurt out and splash out of the can. Also, such accumulated air or gas would affect the accuracy of the fill.

As soon as the roller 343 has caused the cam 331 to close the outlet valve 325, the roller 341 causes the cam 330 to open the inlet valve 310 and permit the flow of food product 104 under pressure into the cylinder 260. At this time the piston 270 has begun to move radially inwardly, and it continues its radially inward stroke until it reaches the

inner limit of that stroke, thereby measuring the charge of food. At the very instant when the piston 270 reaches the inner limit of its stroke (crank on dead centre), the inlet valve 310 is closed by its cam 330 engaging the roller 340, assuming that an empty can M is below the outlet 215, and a charge of food is therefore accurately measured. During this intake cycle, the piston 270 has been moved only by the action of crankshaft 281 on its rod 275, so that the pressure of the liquid flowing into the cylinder 260 does not affect the piston 270, and similarly, the movement of the piston does not affect the back pressure of the product 104 in the tube 200. Closure of the valve 310 also does not affect the back pressure of the product 104 in the tube 200; so it will be seen how this object of the invention has been achieved, namely, of providing a filling valve that will maintain the back pressure of the food product.

As soon as the inlet valve 310 is closed, the roller 342, by its engagement of the cam 331, causes the outlet valve 325 to open, and the material inside the cylinder 260 is dispensed into the container M by the piston 270. It will be noted that an empty can M entered the inlet cycle at the inlet 213 before the inlet valve 310 was closed, so that it was already in position to receive the contents of the cylinder 260. Moreover, it will be noted that the filled can N exits after the valve 325 is closed, giving a sufficient time for any dripping that may occur, although normally with the ball valves 311 of this invention having the self-aligning polytetrafluoroethylene valve seats 316 and the rubber O-rings 317, there is no dripping. The O-rings 317 seal between the valve seats 316 and metal surfaces 320 and 321 while at the same time exerting the necessary pressure to prevent leakage between the ball valve 311 and the valve seats 316. Moreover, the outlet valve 325 is intentionally positioned as close as possible to the bottom of the valve block 257, so that the distance from the valve 325 itself to the discharge lip 215 is short and surface drainage is minimised.

Maintaining the Sterility of the Annular Can-Filling Chamber 212 (Fig. 12)

During their filling, the cans M are maintained in a sterile atmosphere inside the chamber 212 which is defined by the stationary can track 214, a vertical annular wall 350 secured to the can track 214, the rotating flange 241, and a vertical annular wall 351 depending from and secured to the flange 241. The wall 351 is also secured to a flange 352 that is secured to the rim 244. A series of short slots 353 is provided in the wall 351 to permit swinging movement of the fingers 250. Narrow clearances are provided for limited outflow of steam rather than trying to provide rotary seals. Thus, there is a small leakage of sterile gas or steam at the slots 353, more at a clearance 354 between the flange 352 and the can track 214, and at a clearance 355 between the wall 350 and a groove 356 in the flange 341. These clearances help to maintain the filling operation at atmospheric pressure when the steam or other sterile gas is introduced to the chamber 212 from the star wheel chamber 207, and the outward flow of steam prevent entry of airborne bacteria into the sterile chamber 212.

Sterility of the Chamber 256 during Operation (Fig. 12)

A sterile fluid such as cool water that has been sterilised or saturated steam is maintained under low pressure in the chamber 256 during operation of the device, and since the food product 104 itself is sterile, this means that at all times the cylinder 260 is in contact only with sterile fluids which are on both sides of the piston 270. The O-ring 271 in the piston 270 prevents dilution of either fluid. Sterile water is preferable to saturated steam when it is desired to fill with the product 104 at 90—110° F., since it will not heat the product. For filling at, say, 190° F., steam would be preferred, since it would not cool the product.

Equipment for Sterilising the Chamber 256 of the Filler K (Fig. 12)

Inside the pipe 222, a stationary tube 360 goes all the way to the top, where it is threaded to a fitting 361. This pipe 360 serves to supply the chamber 256 and the radially inner end of the cylinders 260 with sterilising steam at first and, later, sterile water. The pipe 360 is connected by a pipe 362 to a reservoir 363, normally containing sterile water, and having a jacket 364 normally containing cold water, circulated by pipes 365 and 366. An inlet closure valve 367, a drain valve 368 and a drain conduit 369 are also provided. The upper end of the reservoir 363 is connected by a conduit 370 to a suitable source of steam, with controls 371 to maintain the proper temperature and pressure. A bleed valve 372 leads from the bottom of the chamber 256 to free it from condensate during presterilisation.

What Happens After the Cans are Filled (Fig. 1B)

The filled cans N are handled in closed sterilised chambers until they have been sealed. They pass along a conveyor O in a sterilised chamber 380 into the closing machine P. Meanwhile, covers 381 are placed in a suitable storage unit 382 and introduced into a cover steriliser Q of any desired type. From there the sterile covers 381 pass to the closing machine P. The closing machine P operates in the normal manner of aseptic closing

machines to seal the cover 381 tightly on the can N. Since no cooking is to be done later, everything is sterile at this point. All interior surfaces of the closing machine P which may in any way come into contact with either the filled sterile cans N or sterile covers 381 are maintained in a sterile condition by the outward flow of sterile gas or steam. The closing machine P is then provided with an outlet through which steam exits to maintain sterility and through which the sealed cans R pass outside the aseptic canning unit along a conveyor S whence the cans R go to a washer, labeller, and case packer.

OPERATION

STEP 1—PRESTERILISATION OF THE SYSTEM

Before running a food product through the aseptic canning system, that system is first treated so that the pertinent parts thereof are in a sterile condition.

In doing this, no solids are added; i.e., the belt 62 is not operated. The valve 34 is closed to the pipe 33, and tap water is introduced into the system through the pipes 36 and 35, the float chamber 41, the conduit 45, the funnel 90, and the pump E, which sends it into the product heater F through the conduit 105 and the inlet tube 117.

With the steam superheater 150 operating, superheated steam, e.g., at 800—1200° F. and at a pressure of 45—50 p.s.i.g. is sent through the inlet 128 into the housing 110. There the impeller blades 145 and baffles 146 send it whirling out into the chamber 132. There it heats the tap water to about 290—300° F., and then the steam is recirculated by the fan blades 141 through the outlet conduit 148.

The heated water and the steam soon sterilise the interior of the heater housing 110. The hot water, under pressure, flows into the conduit 115 and thence into the float chamber 181, which is kept at the same pressure as the chamber 132 by the tube 147. Thus, the conduit 115 and float chamber 181 are sterilised.

At this time the water jacket 197 is empty, its inlet valve 198 being closed and its outlet 199 open to the drain. Hence, the hot water from the heater F courses through the devices I and J, sterilising them. It continues through the conduit 200 to the valve 201, whence it passes out through the drain conduit 202 and back-pressure valve 203, completing sterilisation to this point.

Meanwhile, a source of superheated steam at between 300° F. and 400° F. is introduced through the conduit 205 and valve 204, sterilising the other side of the valve 201 and the remainder of the conduit 200. This steam enters the manifold 300 and flows down through the pipes 306 and elbows 308 into the inlet valve 310, sterilising all these parts. The assembly 211 is being rotated at this time, so that the pistons 270 are moving in their cylinders 260. The no-can no-fill apparatus is disengaged so that the valves 310 and 325 operate as though there were cans on the track 214, and therefore the steam passes through the valves 310 and 325 and the cylinder 260, completing sterilisation of that portion of the device. Steam also enters the filling chamber 212 from the chamber 206 as well as from the valves 325 and sterilises it.

At this time the valve 368 is open; and the water jacket 364 empty. Steam at about 15—20 p.s.i.g. from the conduit 370 passes through the reservoir 363 without condensing and thence flows through the pipes 362 and 360 into the chamber 256, sterilising the inner ends of the pistons 270 and cylinders 260. Some steam, along with steam condensate formed in the chamber 256, is bled out through a valve 372, the orifice of which is of such size as to discharge all the condensate while at the same time maintaining the steam pressure in the chamber 256 at a level sufficient to maintain a temperature of about 250° F.

STEP 2—CHANGEOVER TO NORMAL OPERATION

After sterilisation of the chamber 256 has been assured, the valve 368 is closed and the valve 367 is opened to send cool water into the jacket 364, leaving via the conduit 366. The valve 372 is also closed. Soon the steam condenses in the reservoir 363 and builds up a supply of cool sterile water, which gradually cools off the chamber 256 and fills it with sterile water which is maintained under low pressure (2 to 5 p.s.i.g.) during subsequent operation by the pressure controller 371.

The sterilisation of the entire system including the product heating unit F, the flow-control device G, the temperature-maintaining device I, the cooling means J and the filler K having been completed, cooling water is admitted to the jacket 197 by opening the valve 198, the cooling water usually being recirculated through a valve 373 and conduit 374, with the valve 199 closed. The water flowing continuously under pressure from product heater F through the temperature-maintaining device I will thus be cooled in the cooling device J and discharged through the back-pressure valve 203 and drain conduit 202.

The flow of superheated steam from the conduit 205 is now stopped by closing the valve 204 and changing the three-way valve 201 to cause the cooled sterile water from the cooling device J to flow directly from the tube 200 through the manifold 300 to the plurality of filler tubes 306 and finally into and out of the cylinders 260 through the inlet and outlet valves 310 and 325. The

no-can no-fill device 334 may now be made operative, and sterile cans may be introduced into the filler K from the steriliser L.

Now the valve 34 is turned to send the liquid product 31 from the kettle 30 into the system. The hoppers 60 are already filled with solids, and the screw 66 and belt 62 now carry the solids into the mixer D. At first, as the food pushes out the tap water ahead of it, there is some dilution, so the first few cans R are thrown away.

STEP 3—NORMAL OPERATION

In normal operation, a liquid food component 31, preheated in the kettle 30 to any desired temperature, flows by gravity through the pipe 33, the valve 34, and the pipe 35 into the housing 40. Thence it flows via the conduit 45 and funnel 90 to the pump E. The desired level is maintained by the float 42 and its action on the butterfly valve 54, which closes as the liquid level rises and opens as the liquid level drops.

Meanwhile, solids in the hopper 60, kept from sticking to the walls by the slowly rotating well-spaced pins 74, fall into the metering device 61, where the screw 66 feeds them uphill through a blanching solution or bath 84 or steam. Steam, if used, enters the trough 67 through the orifices 83 in the tube 82; while water other than that condensed from steam can enter through the tube 86 and nozzles 87. The water level is maintained by the opening 88, or if no water bath is desired, the water is drained out as it condenses through the opening 89.

The blanched solid components are metered by the screw 66, whose speed and therefore measure is determined by the speed of the motor H and by the local transmission 81 on each screw drive shaft 77. The measured solids fall through the outlet 68 onto the belt 62 and are carried to the chute 94, whence they fall into the funnel 90.

In the funnel 90, the slowly rotating hollow screw 97 mixes the liquid and solids together, and its tip 98 prevents the solids from bridging the pump inlet 93. The pump E, operated by the motor H, sends the mixture 104 through the pipe 105 to the rotating inlet tube 117 of the product heater F.

As the mixture 104 pours out from the rotating spout 122, it flows gently down the walls 113 and 114. The spout 122 is rotating at between 30 and 80 r.p.m. so that tender frangible solids are not damaged and so that the walls 113 and 114 are always covered with the food product 104. As it gently flows down the walls 113 and 114, the product 104 is heated by superheated steam that is whirled circularly around in the chamber 132 by the fast-rotating impeller blades 145. The high-temperature superheated steam sweeps the surface of the product mixture without mixing with the product, and heat transfer occurs at the surface. The walls 113 114 are at all points cooler than the food product flowing down them; so there is no danger of the food burning on them. The cooling channel 129 is filled with circulating cool water, causing the steam to condense on the wall area 158 and keep the boundary between the steam and the product cool, thereby preventing burn-on at the surface of the wall 158.

The whirling of the superheated steam prevents intermixing of the steam with the product, prevents the food product from spattering on hot metal surfaces of the housing 110 or fan 135, and prevents any of the food product from being entrained with the steam being recirculated through the superheater 150.

The cooled steam, still dry, is expelled by the fan blades 141 into the upper chamber 130 and sent to the superheater 150 by the conduit 148, for reheating and recirculation. The conduit 147 connecting the chamber 132 to the housing 180 keeps the latter at the same pressure as the former.

The heated product 104 leaves the housing 110 substantially without dilution (unless dilution is desired) and may even be somewhat concentrated, if desired. Normally, however, it will leave with exactly the same water content as it had when it entered the heater F.

The heater product (at about 290° F. or within the 275° to 300° F. range) leaves the heater F through the conduit 115 and enters the float chamber 181. Its level here is dependant on the amount of product being dispensed by the filler K and the pumping rate of the pump E. The float 183 follows the product level, and when the float 183 rises or gets lower, it closes or opens the needle valve 187, varying the pneumatic pressure through the tube 194 to the pneumatic amplifier 195. The amplifier 195 controls the device H to speed it up or slow it down. Variation of the speed of the device H controls the speed of the pump E and of the metering screws 66 for the solid components of the mixture 104. As the level in the chamber 181 rises, the pump E and screw 66 slow down; when the level falls in the float chamber 181, they speed up. Also, by the effect of the pump speed on the liquid level in the float chamber 41, the valve 54 metres the liquid component. Thus, any change in the filling rate automatically controls the metering of the components into the heater F.

The effect of the metering rate on the heating action, as well as any other heating effect, causes actuation of the temperature controller 161, and counter-measures are instantly taken in the burner 151 to raise or lower the steam temperature to bring it back

to the desired level. Thus, all the operations are slaves of the filler K.

From the float chamber 181 the food product flows under the pressure exerted at the chamber 132 through the insulated tube 196 of the temperature-maintaining device I, where the high temperature is prolonged for the few seconds necessary to ensure complete sterilisation of the product 104.

The sterilised product 104 is then cooled to the desired level (to avoid undesirable chemical effects) in the cooler J and passes to the filler K through the pipe 200. Since the valve 201 is used only during pre-sterilisation and since it offers no obstruction to free flow of the mixture 104 during normal operation, the system between the pump E and the filler inlet valves 310 may be considered valveless, as may the system before the pump E.

The cooled sterile product 104 enters the manifold 300 and flows into the pipes 306 to the inlet valves 310. The filler assembly 211 is always rotating; so some inlet valves 310 are open while others are closed, and vice versa; hence the product is always moving out of the pipe 200 and moves intermittently in the pipes 306.

As the assembly 211 rotates, the fingers 250 pick up empty sterile cans M from the star wheel 206 and carry them along the track 214 beneath an outlet spout 215. When any finger 250 fails to pick up a can M, for whatever reason, the no-can no-fill lever 345 is actuated and prevents the rollers 340 and 342 from opening the pertinent outlet valve 325 or closing the pertinent inlet valve 310. Otherwise, the rollers 340 and 342 engage the cams 331 and 330 successively to first close the inlet valve 310 just as the product flowing therethrough has filled the cylinder 260 and then to open the outlet valve 325, so that the piston 270 ejects the product 104 into the can M. Filling continues until the roller 343 closes the outlet valve 325 at the end of the outer stroke of the respective piston 270, the roller 341 immediately thereafter opening the inlet valve 310 to receive another charge of product into the cylinder 260.

Soon after the outlet valve 325 closes, the cam 252 reaches the flat part 253 of the cam track 228, and the finger 250 retracts slightly, slowing down the sterile can N filled with its sterile product, just as it makes the transfer from the track 214 to the outlet star wheel 217. From there, the can N passes by the conveyor O to the closing machine P, where it is closed under sterile conditions. Thence the closed cans R are carried away by the conveyor S.

WHAT I CLAIM IS:—

1. A continuous aseptic canning process for a product consisting of food containing large particles, comprising continuously pumping a said food; spreading said pumped food into a moving film; contacting, without intermixture, the surface only of said film with superheated steam under pressure sufficient to prevent its condensation so as to raise the temperature thereof in the range of 275° F. to 300° F. while maintaining all other surfaces of said film in contact with cooler temperature bodies; sterilising said food at said temperature; cooling said food below its flash temperature at atmospheric pressure; and measuring said food and dispensing it under sterile conditions at atmospheric pressure into sterile containers while holding the back pressure between said contacting step and said measuring step at the point of said measuring step.

2. A process according to claim 1 in which the dispensing rate controls the pumping rate.

3. A process according to claim 2 in which, prior to pumping, the liquid and solid components of the food are separately metered into a mixture that forms the food to be pumped, the pumping rate controlling the metering rate of each component.

4. A process according to claim 3 in which several components are individually metered by independent metering devices, the metering rate of each component being controlled partly by the pumping rate and partly by individual adjustment of each metering device.

5. In an aseptic canning system for carrying out a process according to claim 1, an apparatus comprising the combination of metering means for both solid and liquid components of the food, mixing and feeding means, a product heater having a supporting surface for distributing a product to be heated over the surface in a thin, gently-moving stream, means for continuously pumping the food, means for continuously contacting the surface only of the stream with hot gas, means for keeping the supporting surface at all places cooler than the product in contact with it, and a closed housing having a product inlet, a product outlet near the bottom of the housing, pumping means for pumping the mixture of the liquid and solid food to the heating means inlet, a filler having means for aseptically dispensing the mixture into sterile containers, and conduit means for connecting the filler to the outlet from the heating means, the conduit means having flow-responsive means therein that responds to the dispensing rate of the filler, means responsive to the flow-responsive means for controlling the rate at which the pumping means operates, means for sterilising food containing large particles at a temperature in the range of 275° F. to 300° F. and under sufficient pressure to prevent flashing of the food, means for cooling the food below its flash temperature at atmospheric pressure, means for measuring and dispensing the food

at atmospheric pressure, and means for holding the back pressure between the contacting step and the measuring step at the point of the measuring step.

6. An apparatus according to claim 5 in which the pumping means comprises a variable speed positive-displacement pump and in which the conduit means has a float chamber with a float whose level is determined by the dispensing rate of the filler and the pumping rate of the pump, the level of the float operating means for varying the speed of the pump.

7. An apparatus according to claim 6 having means for metering liquid and solid components into a mixture, the metering means being controlled by the speed of the pump.

8. An apparatus according to claim 6 having means connected to the outlet of the float chamber for maintaining the temperature at which the mixture was heated in the heater for a time sufficient to complete sterilisation of the mixture, and means connected to the temperature-maintaining means for cooling the mixture on the way to the filler.

9. An apparatus according to claim 8 wherein the filler has a plurality of product-measuring means, each with inlet means connected to the cooling means, dispensing means, a sterile chamber in which sterile containers receive the mixture from the dispensing means, and means for sequentially and cyclically closing the inlet means, opening the dispensing means, closing the dispensing means, and opening the inlet means, the heater exerting pressure on the product sufficient to propel the product therefrom to the filler and the filler maintaining the back pressure to the heater.

10. An apparatus according to claim 9 in which the filler has a plurality of filling cylinders, each with a piston and an end toward and away from which the piston moves, each cylinder having an off-on inlet valve and an off-on outlet valve; piston-reciprocating means; means for cyclically (1) closing each inlet valve when its associated piston reaches the inner limit of its stroke, (2) opening each outlet valve immediately after closure of its associated inlet valve to dispense the mixture, (3) closing each outlet valve at the radially outer limit of the stroke of its associated piston, and (4) opening each inlet valve immediately after closure of its associated outlet valve; and conduit means for connecting each cylinder inlet valve at all times to the outlet from the heating means, the conduit means having flow-responsive means therein that responds to the dispensing rate of the filler; and means responsive to the flow-responsive means for controlling the rate at which the pumping means operates to make it correspond to the dispensing rate.

11. An apparatus according to claim 10 having means for feeding a liquid food component at a metered rate and means for feeding presized pieces of solid food into the liquid at a metered rate for supplying the resultant mixture to the pumping means.

12. An apparatus according to claim 11 having means controlled by the pumping means for varying the feed rate of both the liquid and solid components separately, according to the pumping rate.

13. An apparatus according to claim 12 having means for metering liquid and solid components into the mixture, the metering means being controlled by the speed of the pump.

14. An apparatus according to claim 13 having several means for metering the solid components, each driven by the pump and each having means for separately varying the quantity metered.

15. An apparatus according to claim 5 in which the solid metering means comprises a conveyor belt, at least one hopper for solid components adjacent to the belt, a trough extending slightly uphill out of each hopper and having an outlet over the belt, a metering screw in each trough for feeding solid components from each hopper to the belt and means for driving each screw.

16. A metering means according to claim 15 having means for supplying each trough with a blanching agent.

17. A metering means according to claim 15 in which each trough has a steam inlet along its lower wall.

18. A metering means according to claim 15 having a single main drive shaft for all the metering screws and individual means for varying the speed of each screw.

19. A metering means according to claim 18 wherein all the troughs are at one end mounted rotatably on the main drive shaft, and wherein means are provided adjacent the other end of each trough for adjusting its degree of tilt.

20. A metering means according to claim 15 having a shaft mounted near the bottom of each hopper parallel to and above the screw, a plurality of rods each extending from the shaft in a plane perpendicular to the shaft and spaced widely from each other along the shaft and distributed angularly about the shaft, and means for rotating the shaft.

21. A metering means according to claim 20 wherein the rods are curved in an arc presenting a convex surface to their direction of rotation with the shaft, whereby particles easily slide off the rods.

22. A metering means according to claim 15 characterised by a hopper, a trough extending slightly uphill out of the hopper and having an outlet at its uphill end, a hollow metering screw in the trough for feeding solid components from the hopper and means for

driving the screw at a variable predetermined rate.

23. A metering means according to claim 22 having a shaft parallel to the screw and above it, a plurality of curved rods projecting out therefrom each in a separate plane perpendicular to the shaft, each plane being widely spaced from the other planes, and means for rotating the shaft.

24. An apparatus according to claim 5 in which the mixing and feeding means comprise a mixing chamber having an inlet and a bottom outlet and a moving mixing member with an offset tip at its lower end wiping the outlet of the mixing chamber.

25. A mixing and feeding means according to claim 24 wherein the mixing member is a rotating hollow mixing screw with an offset tip at its lower end.

26. A mixing and feeding means according to claim 24 or 25 wherein the pump has its inlet at the outlet from the mixing chamber.

27. An apparatus according to claim 5 in which the mixing and feeding means include in combination a liquid-metering chamber having a bottom inlet, a side outlet, a float, and a butterfly valve in the inlet controlled by the float, means for continuously supplying a liquid food component to the inlet, a mixing chamber connected to the side outlet by a substantially horizontal conduit and having an open upper end and a bottom outlet and a hollow mixing screw with an offset tip at its lower end wiping the outlet of the mixing chamber; means for emptying solid components into the open upper end of the mixing chamber and a pump having its inlet at the outlet from the mixing chamber.

28. An apparatus according to claim 5 wherein the filler comprises means for maintaining the back pressure in the system without back-pressure valves between the filler and the pumping means.

29. A continuous aseptic canning process according to claim 1 as described herein with reference to the accompanying drawings.

30. An apparatus according to claim 5 as described herein with reference to the accompanying drawings.

31. A can of food prepared according to the process set forth in any of claims 1 to 4.

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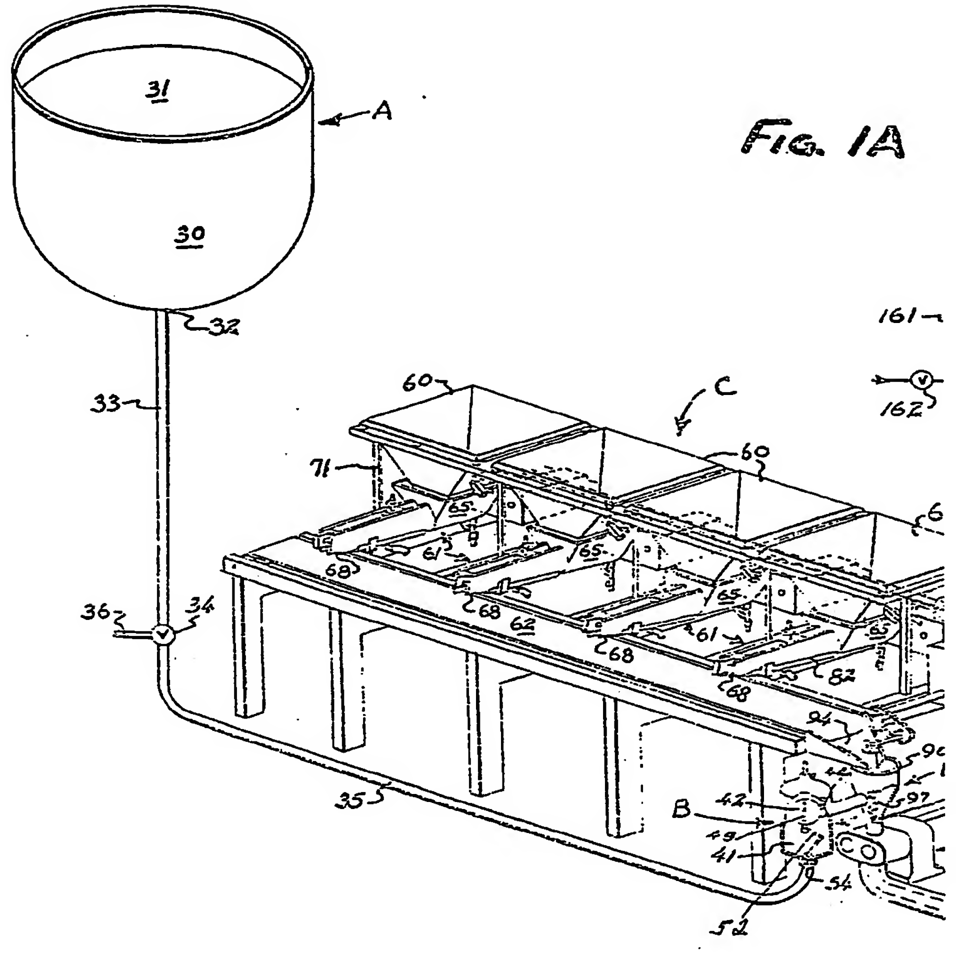
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FIG. 1A

FIG. 1A

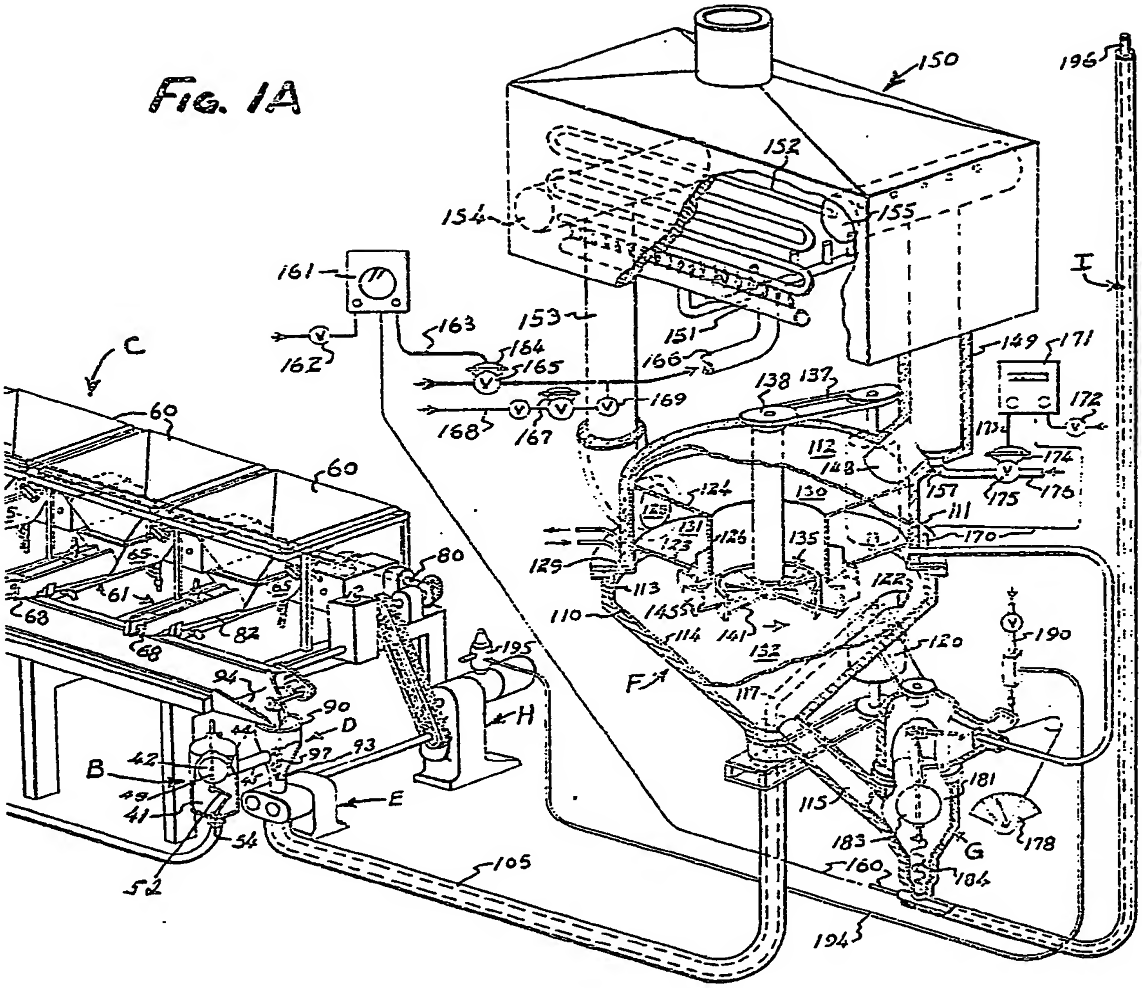
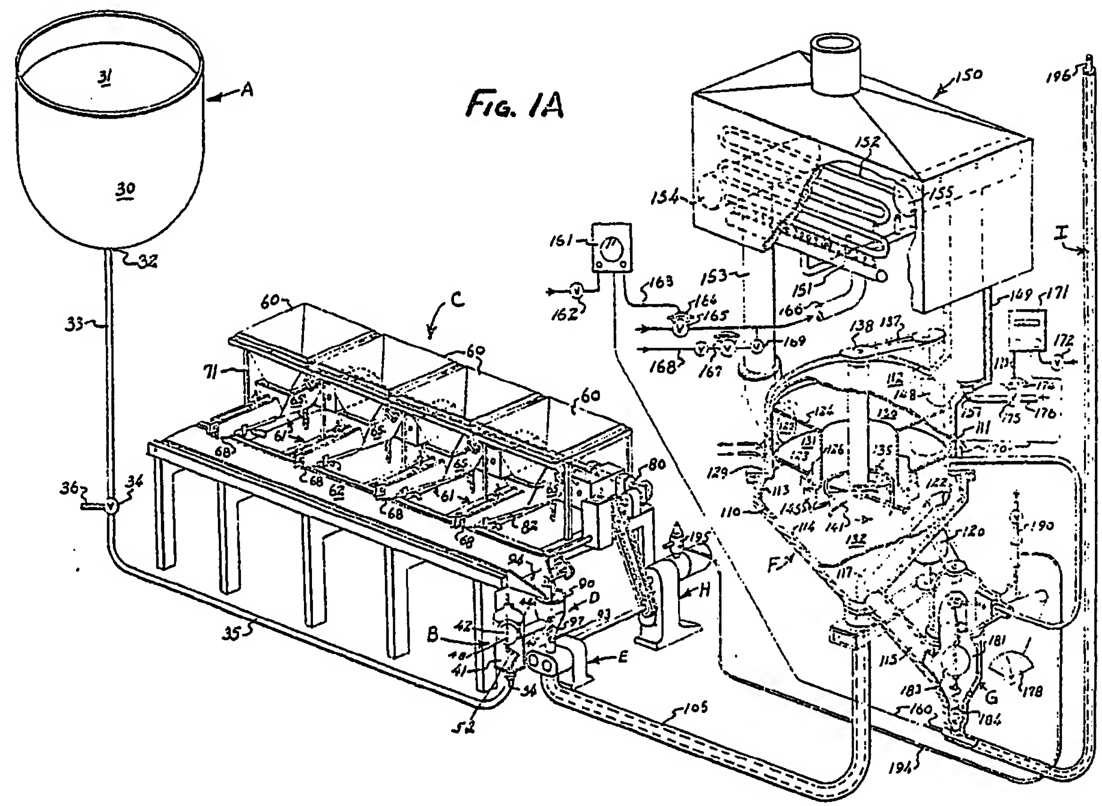


Fig. 1A



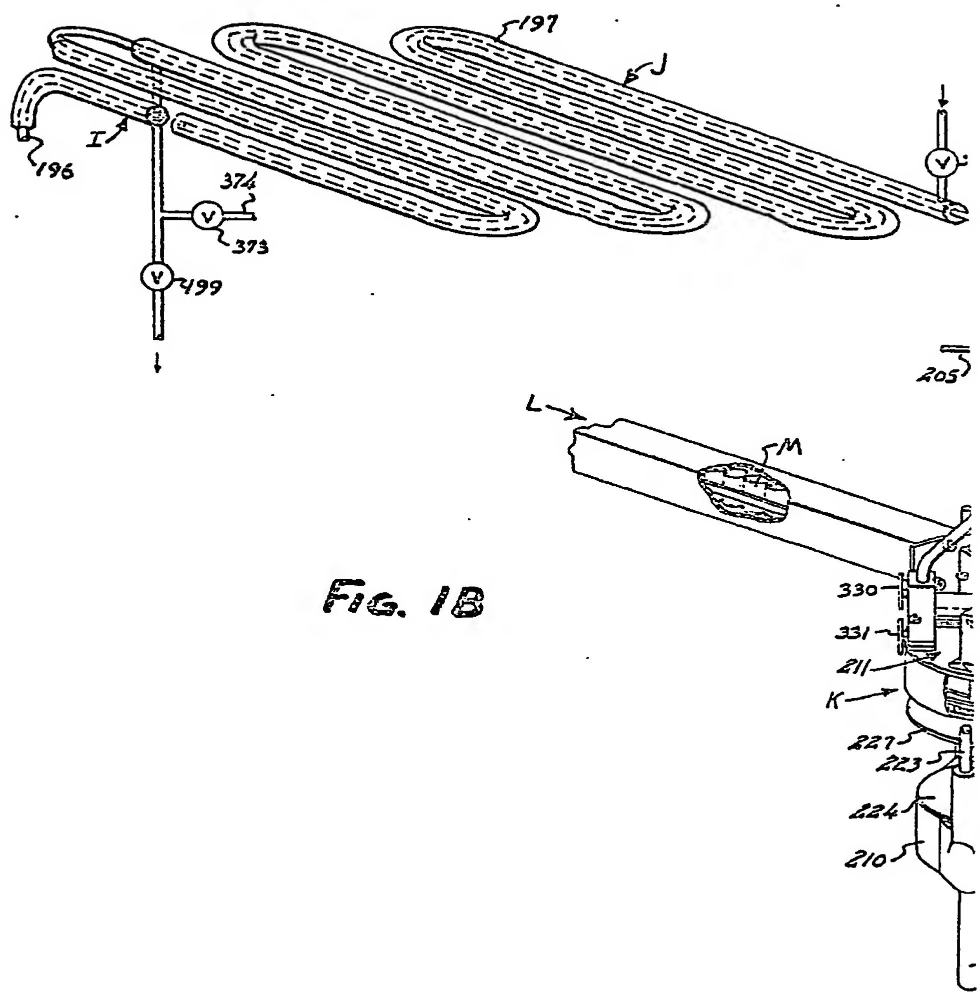
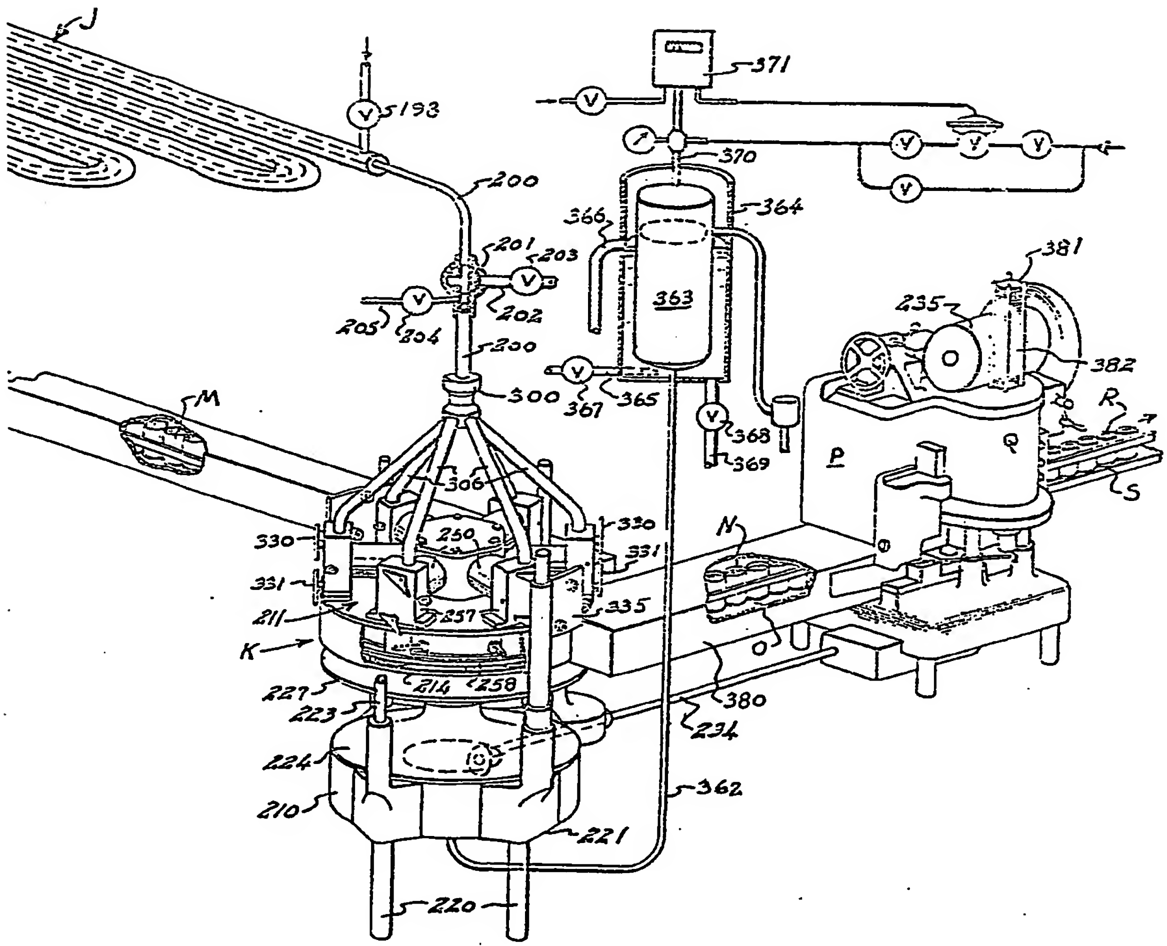


FIG. 1B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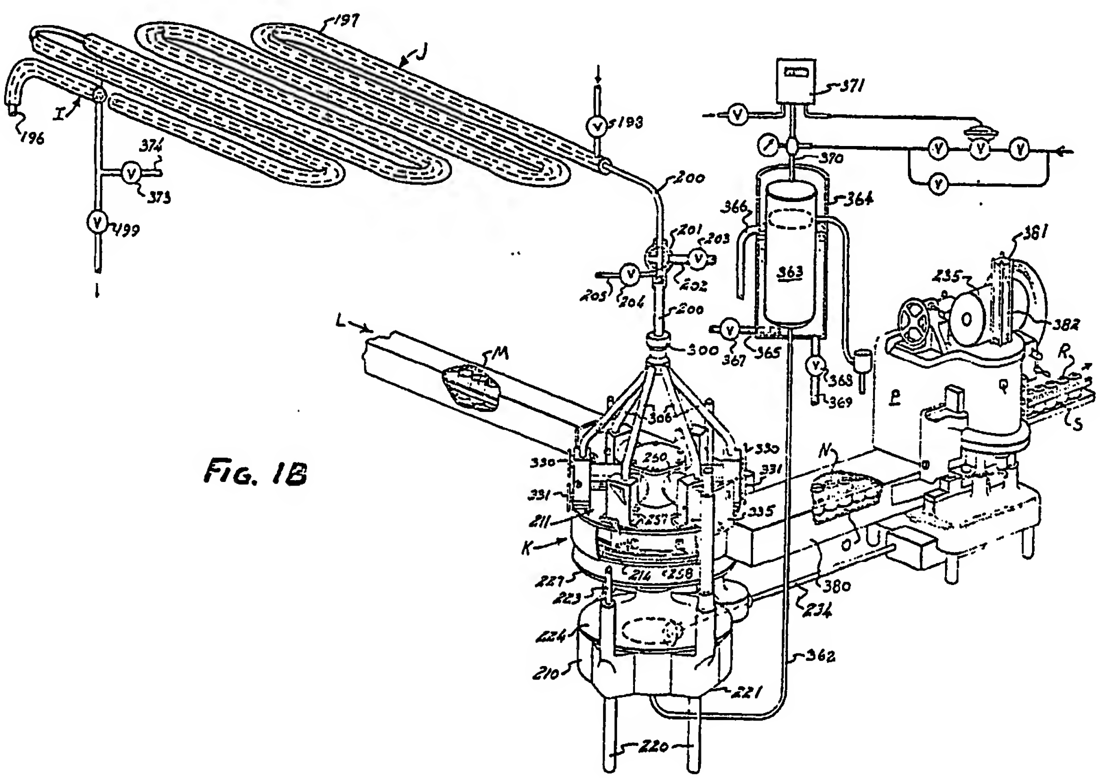
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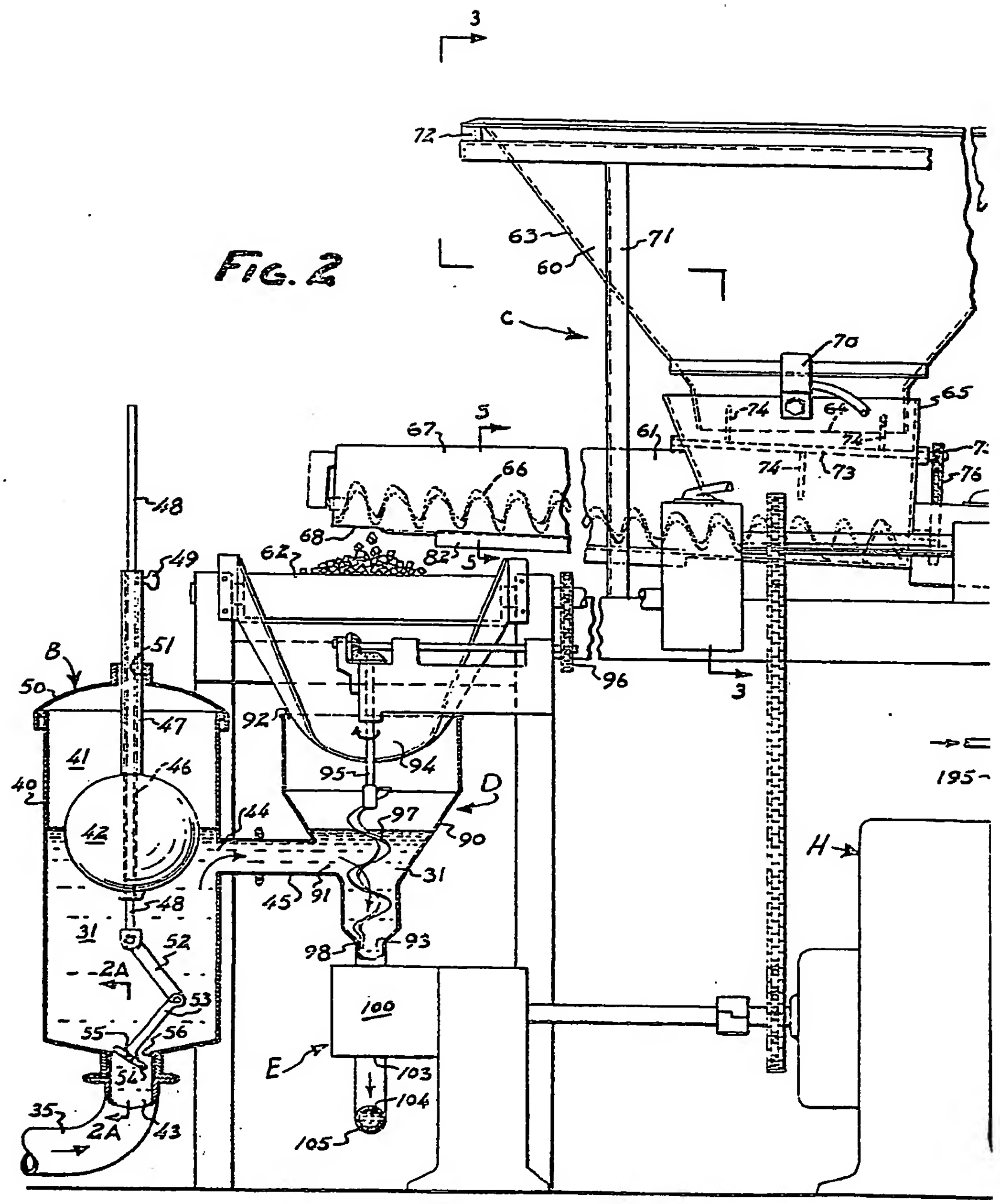
FIG. 1B

FIG. 2



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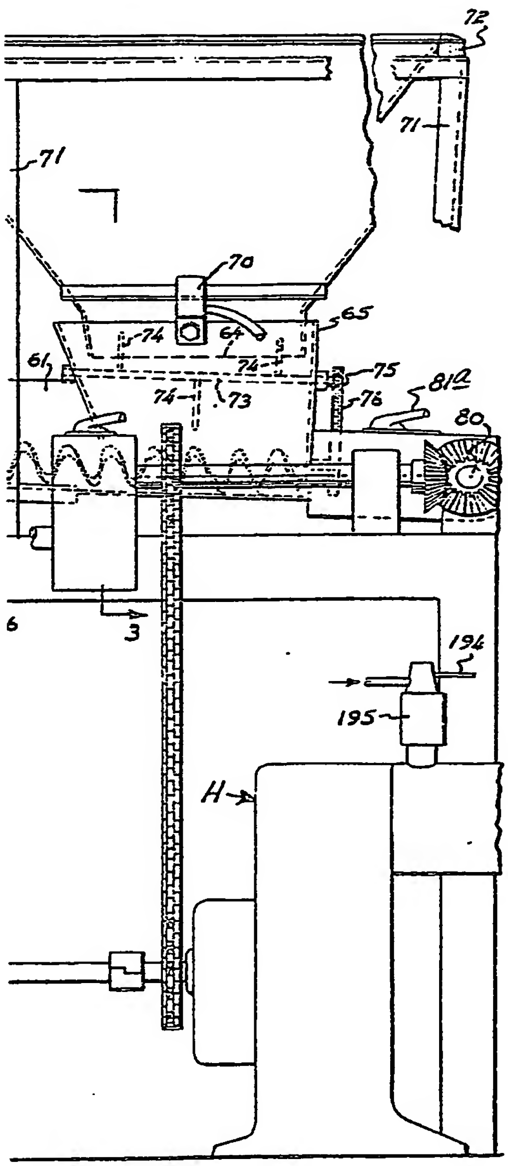


FIG. 2A

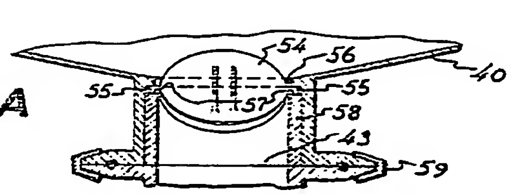
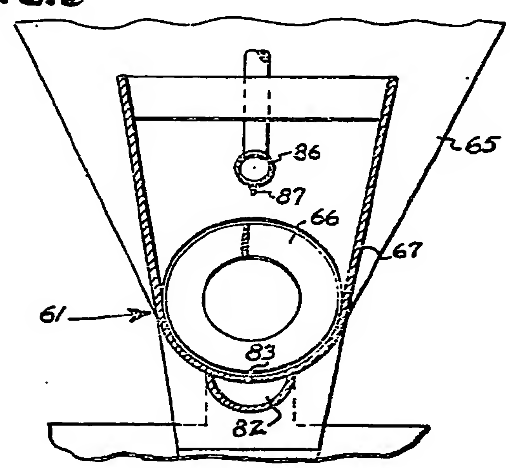


FIG. 5



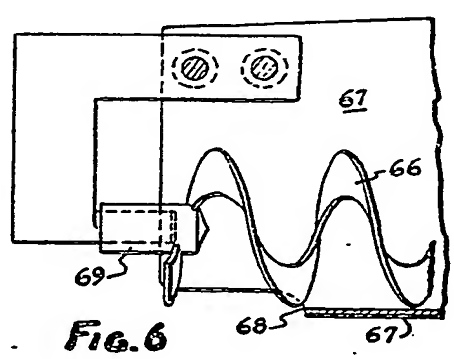


FIG. 6

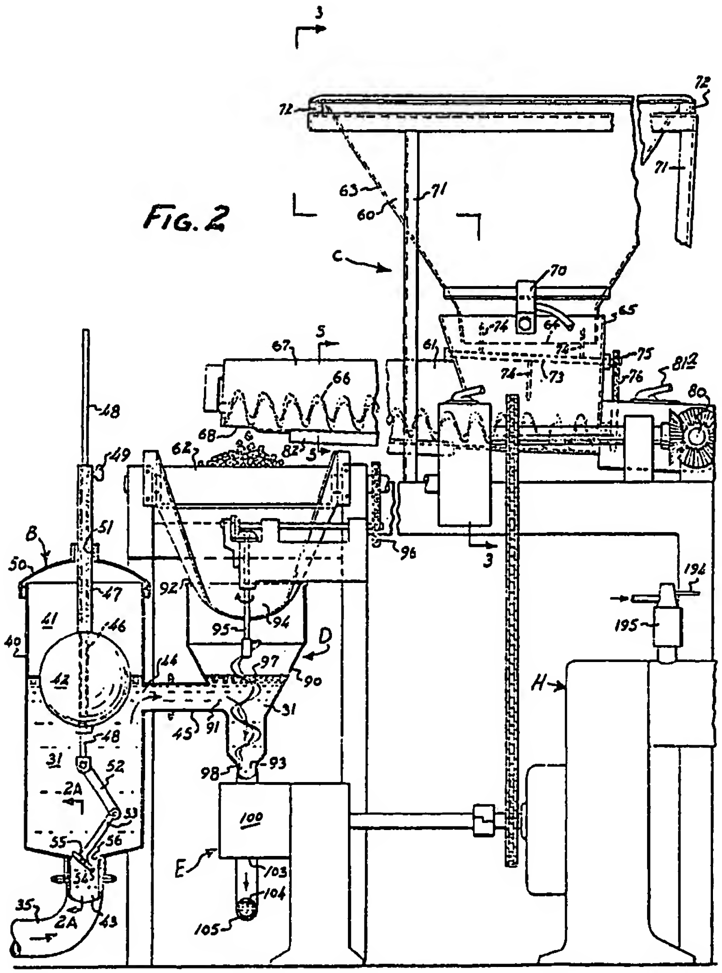


FIG. 2

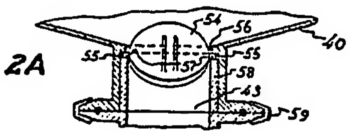


FIG. 2A

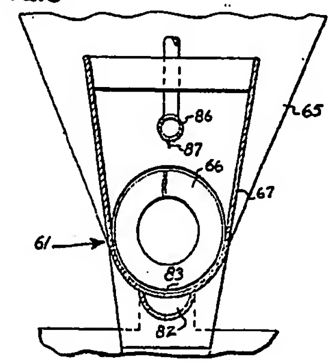


FIG. 5

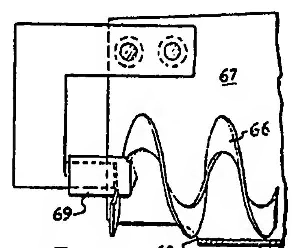
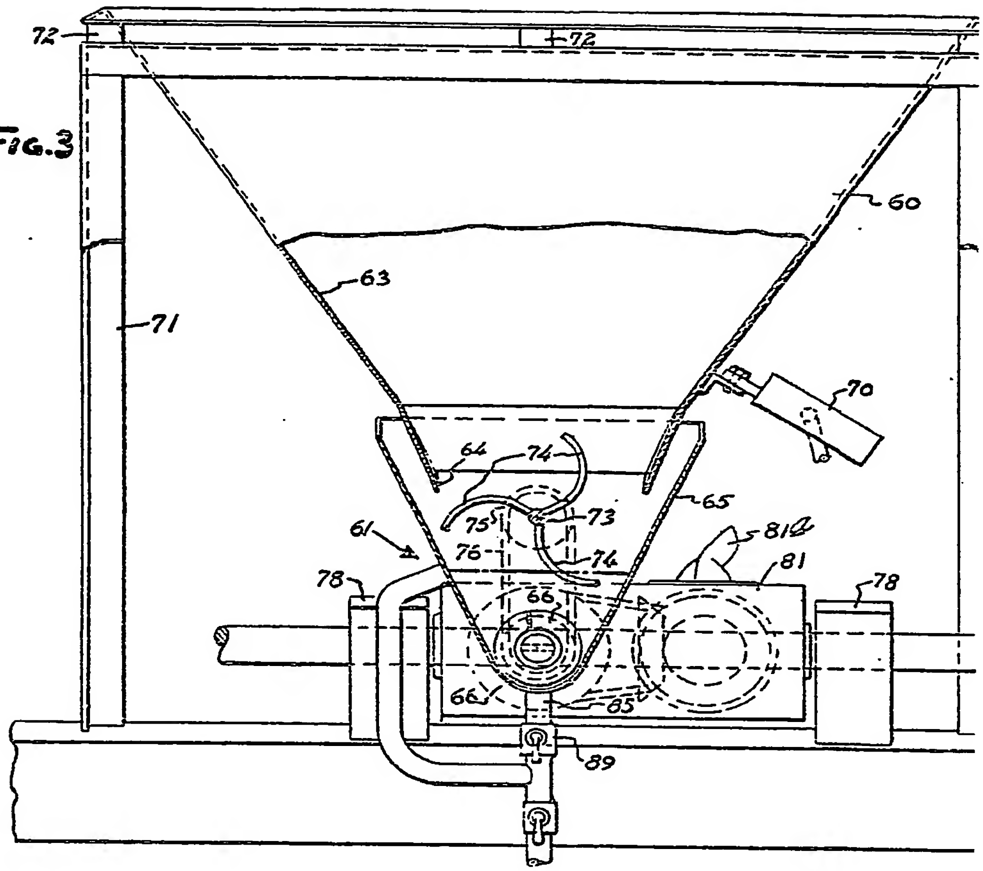


FIG. 6

FIG.3



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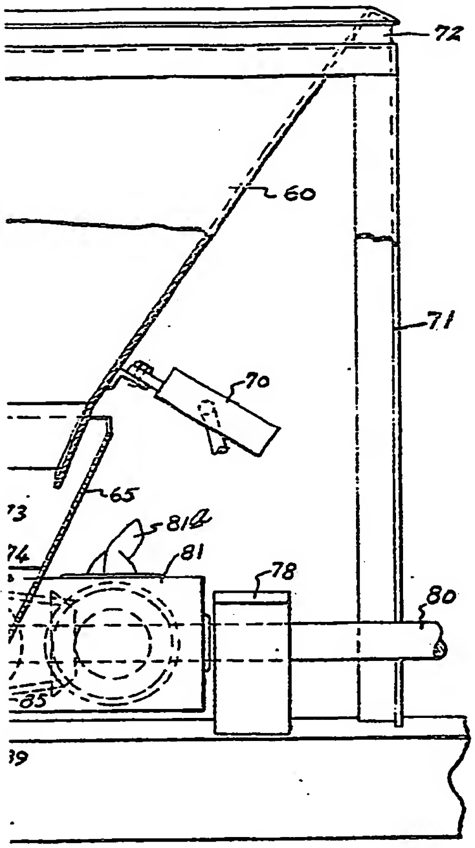
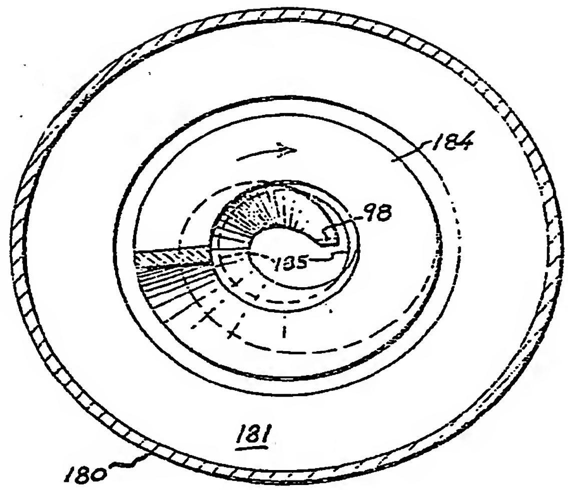


FIG. 10



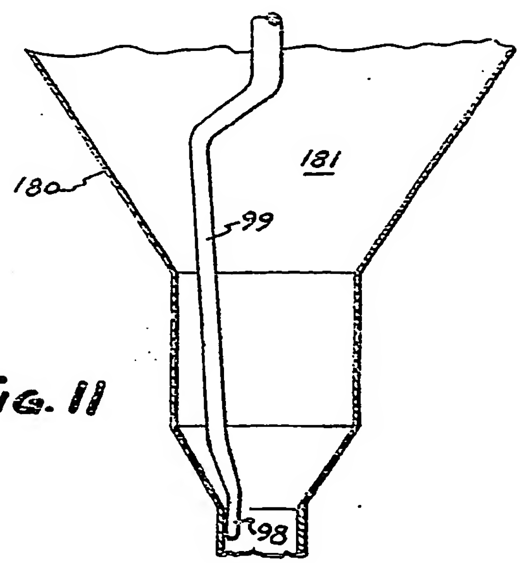


FIG. 11

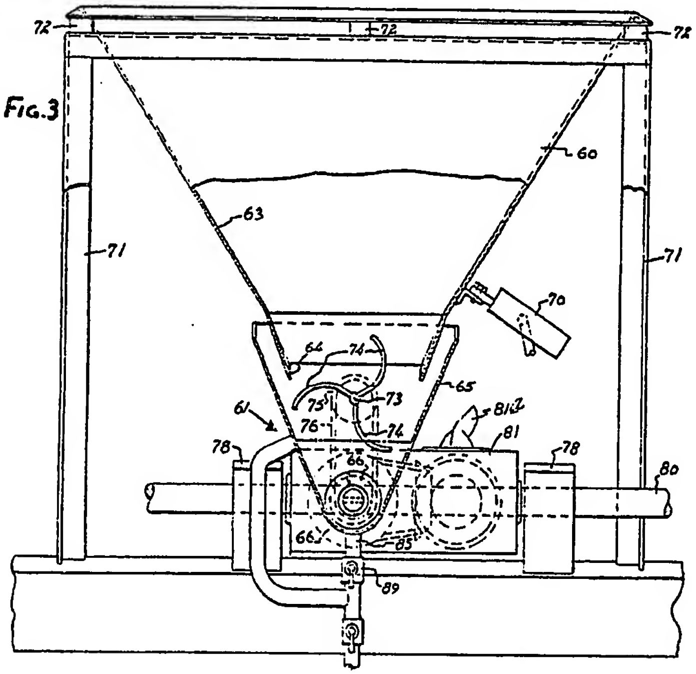
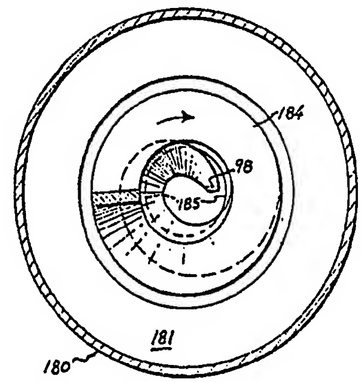


Fig. 3

Fig. 10



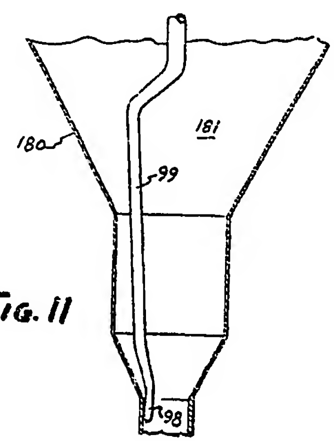


Fig. 11

Fig. 4

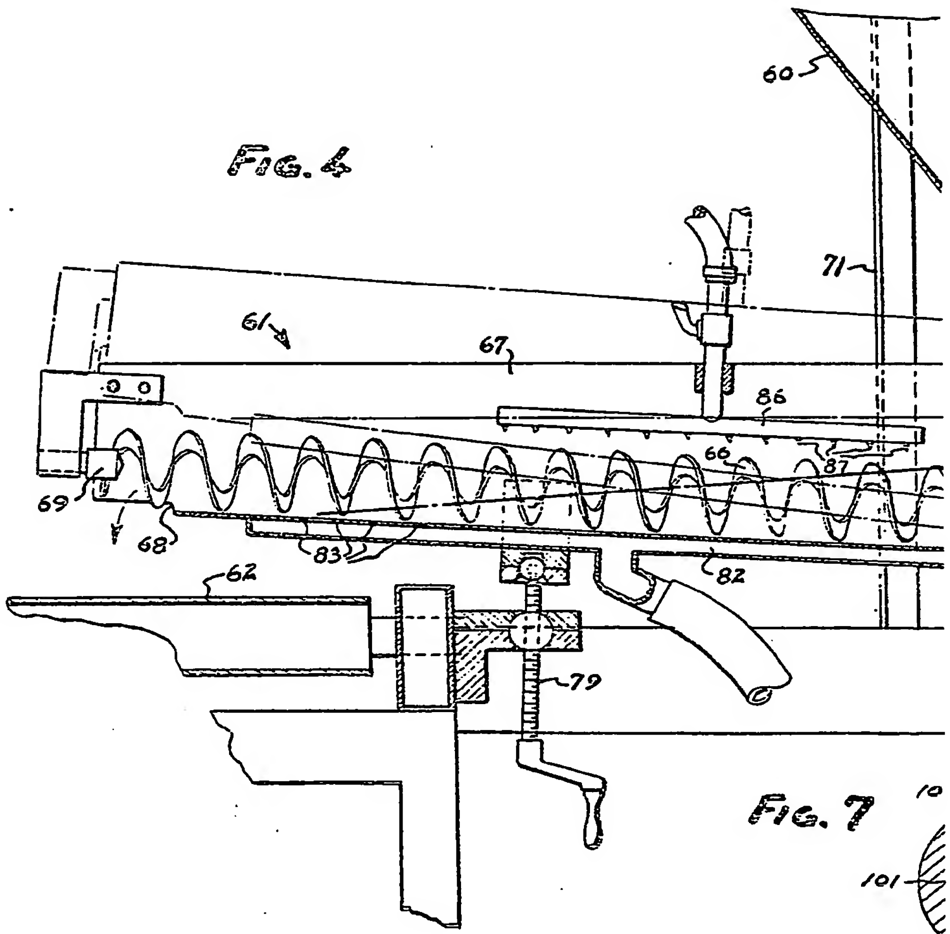


Fig. 7

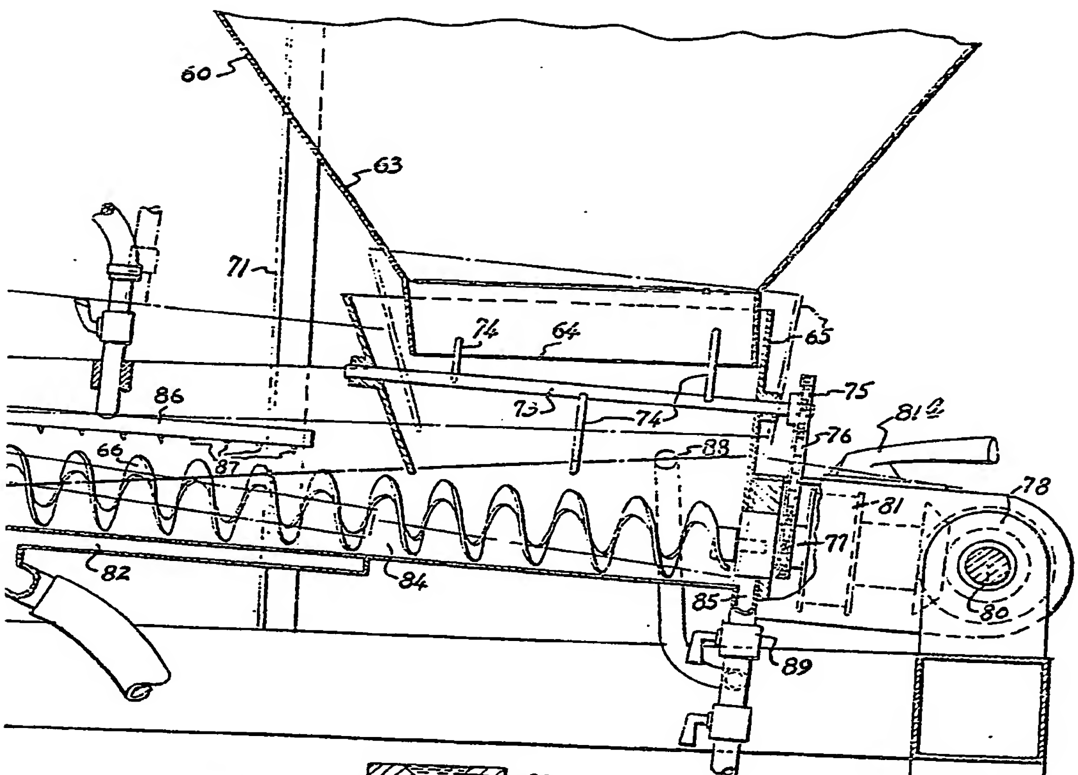

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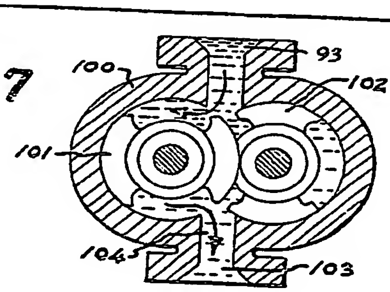
FIG. 7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Sheet 5

FIG. 4

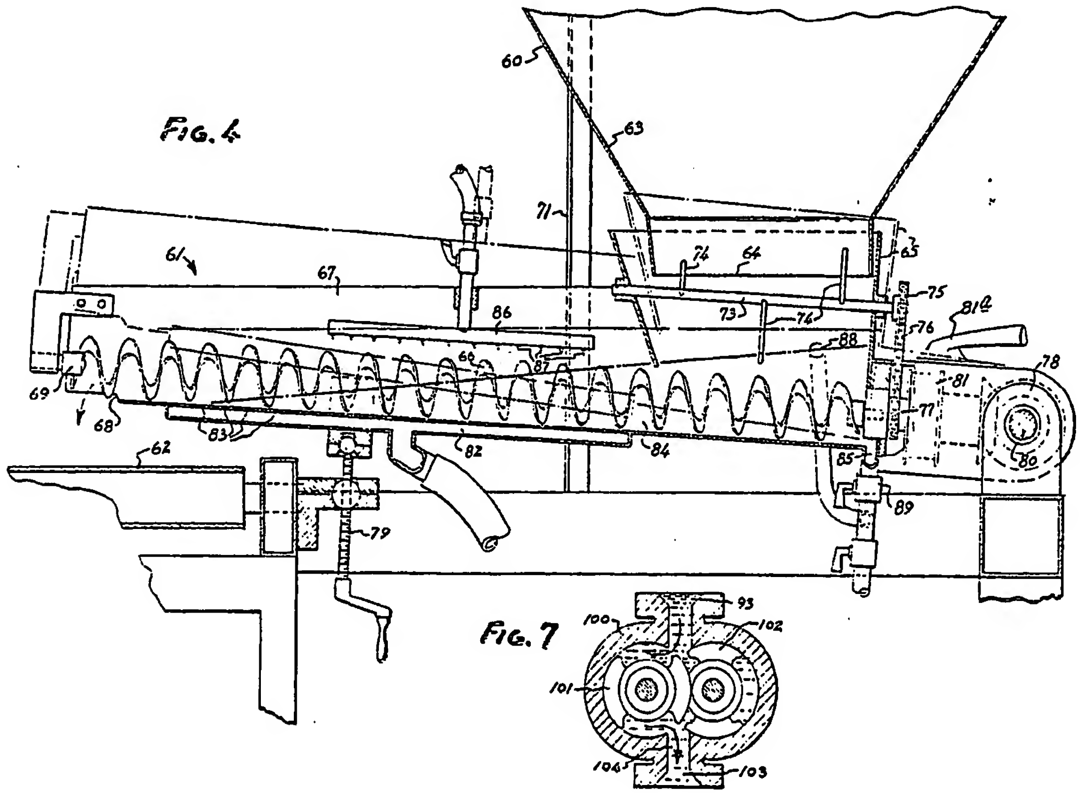
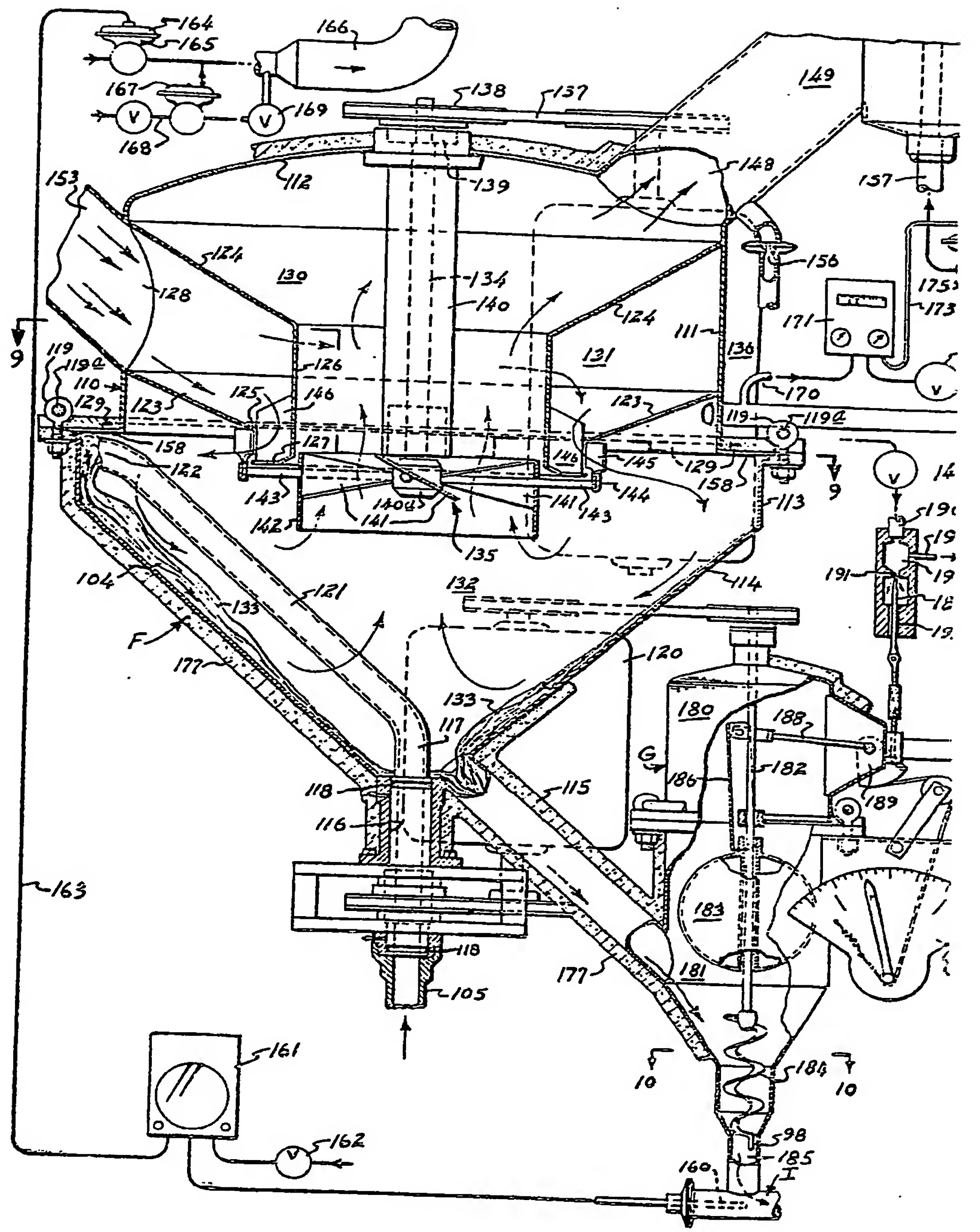


FIG. 7



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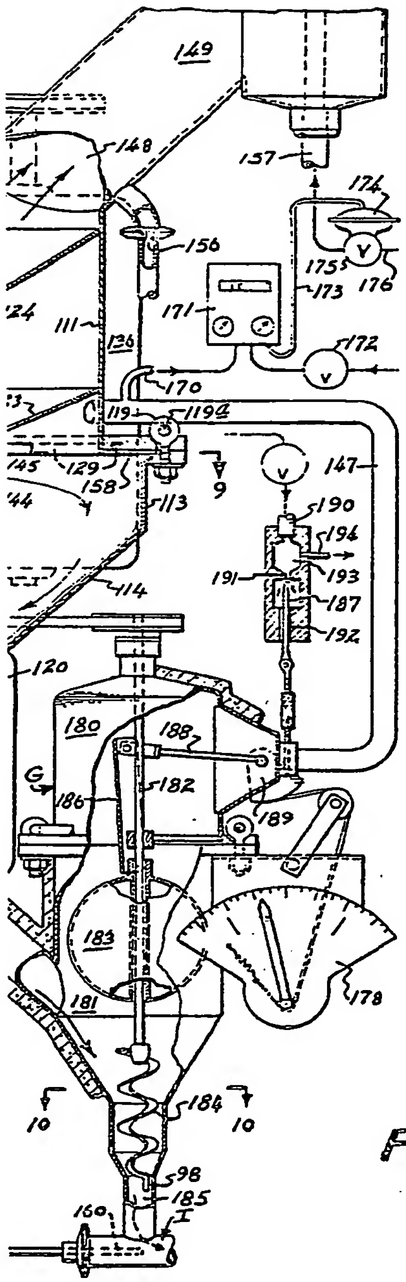
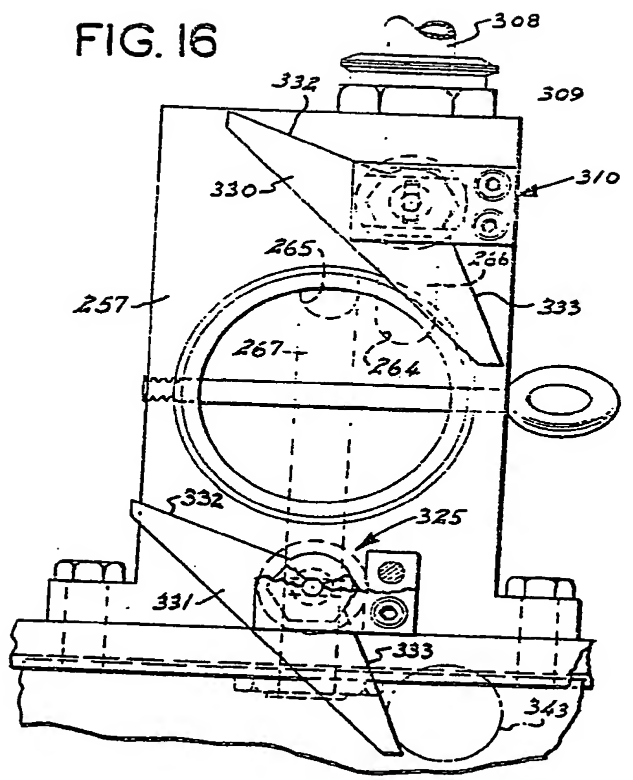


FIG. 8

FIG. 16



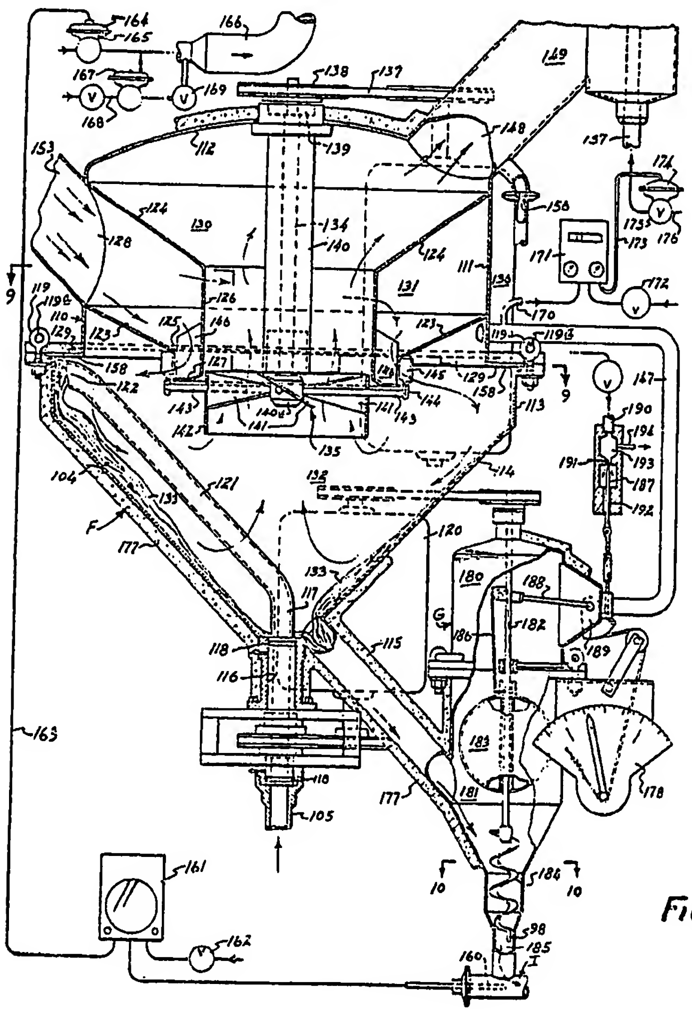


Fig. 8

FIG. 16

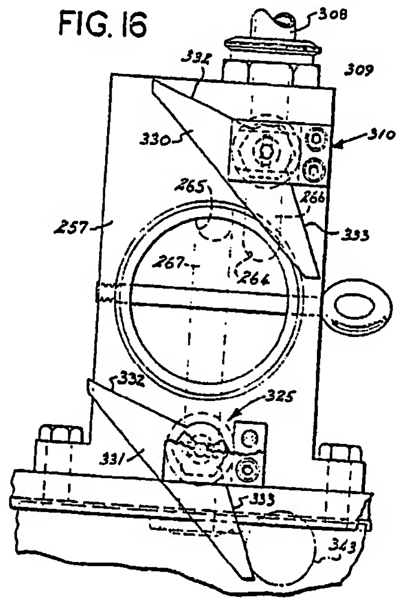


Fig. 9

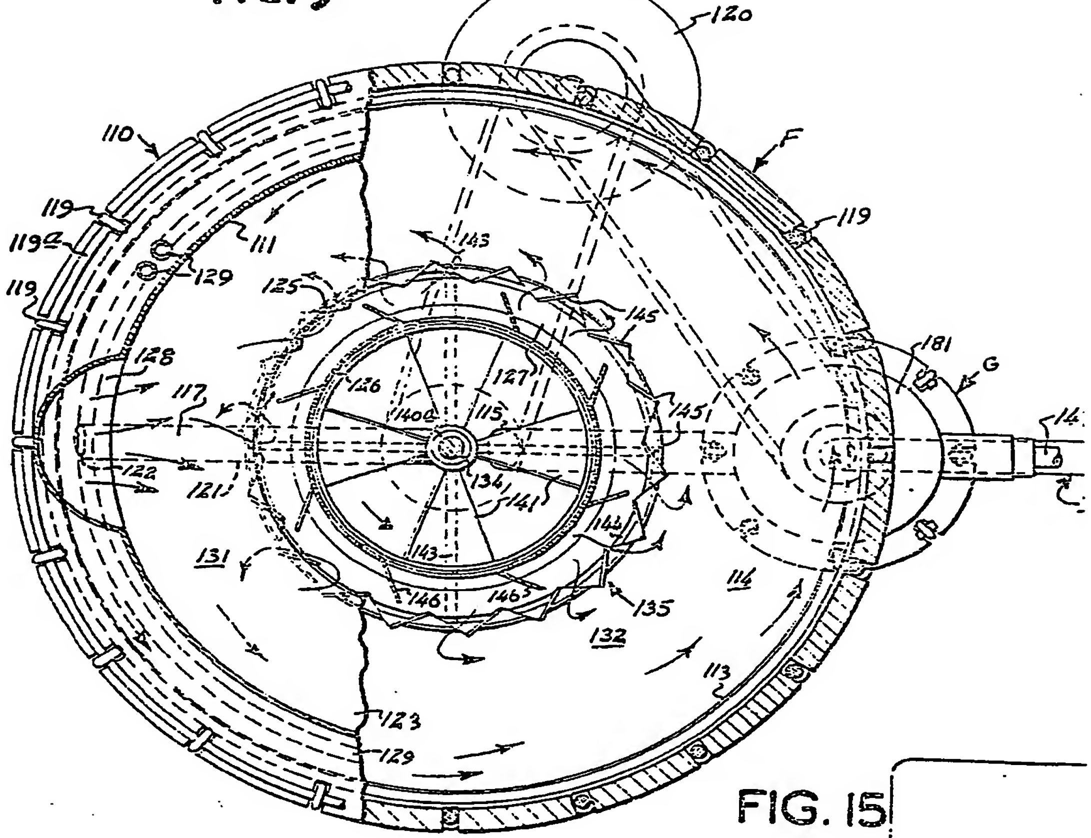

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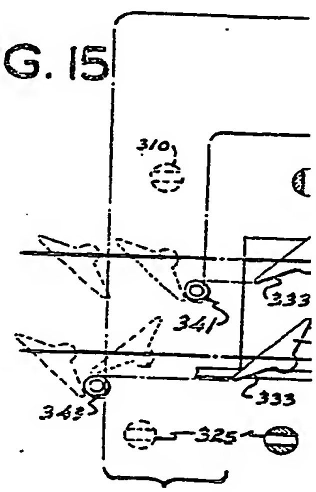
FIG. 15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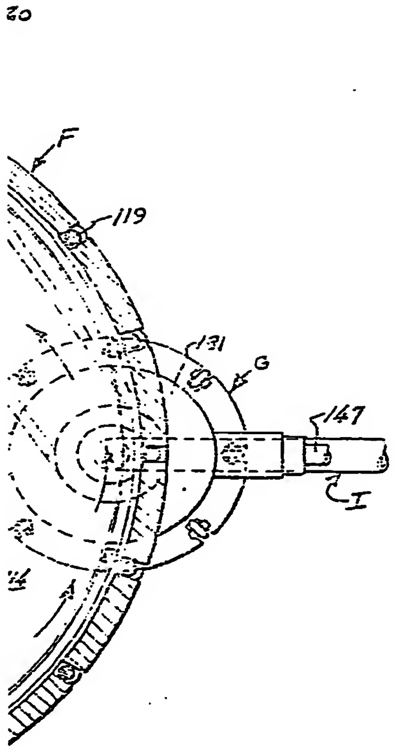
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FIG. 17

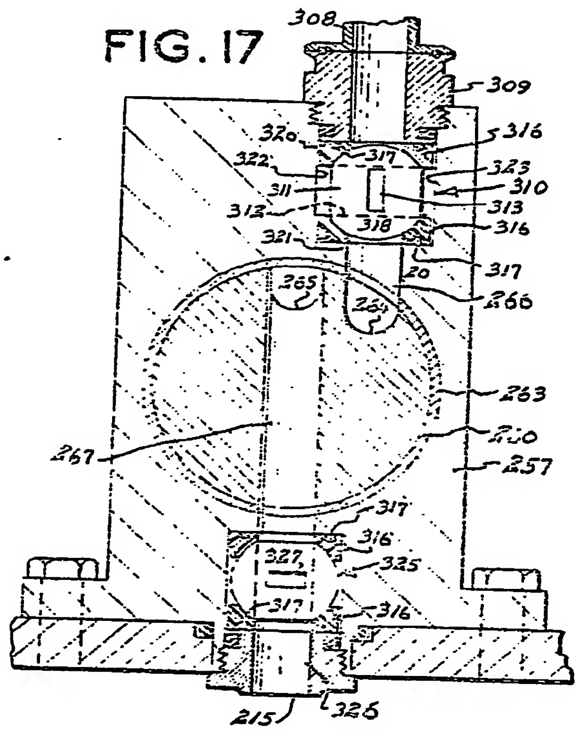
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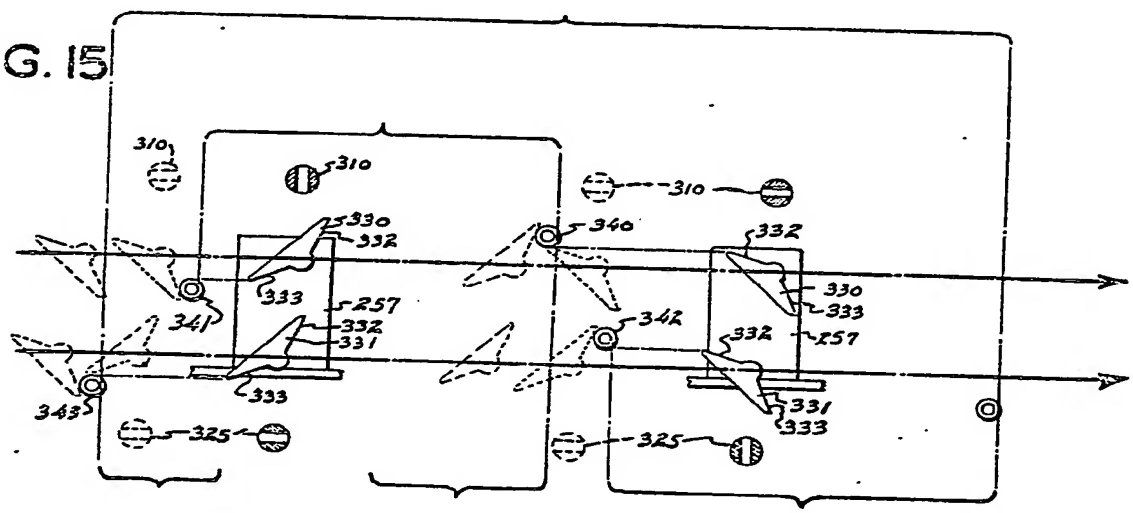
FIG. 15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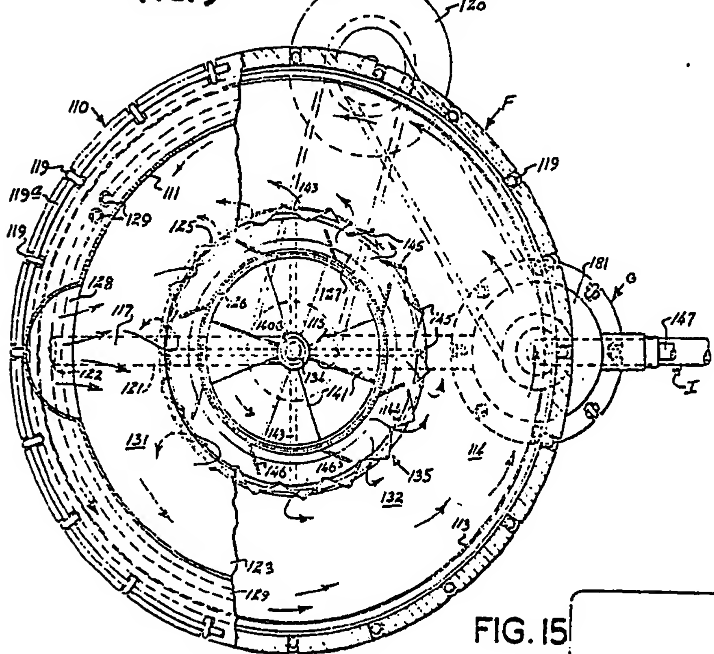
Sheet 7

FIG. 9



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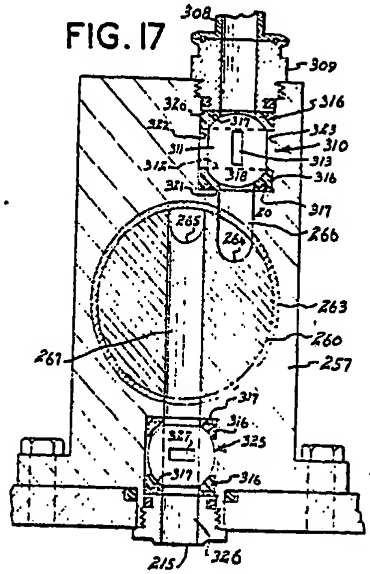

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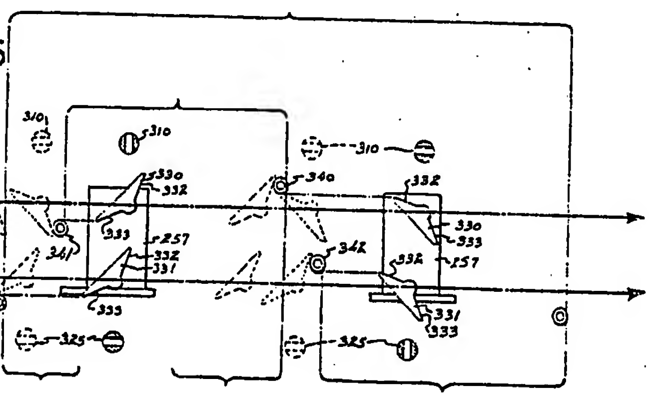

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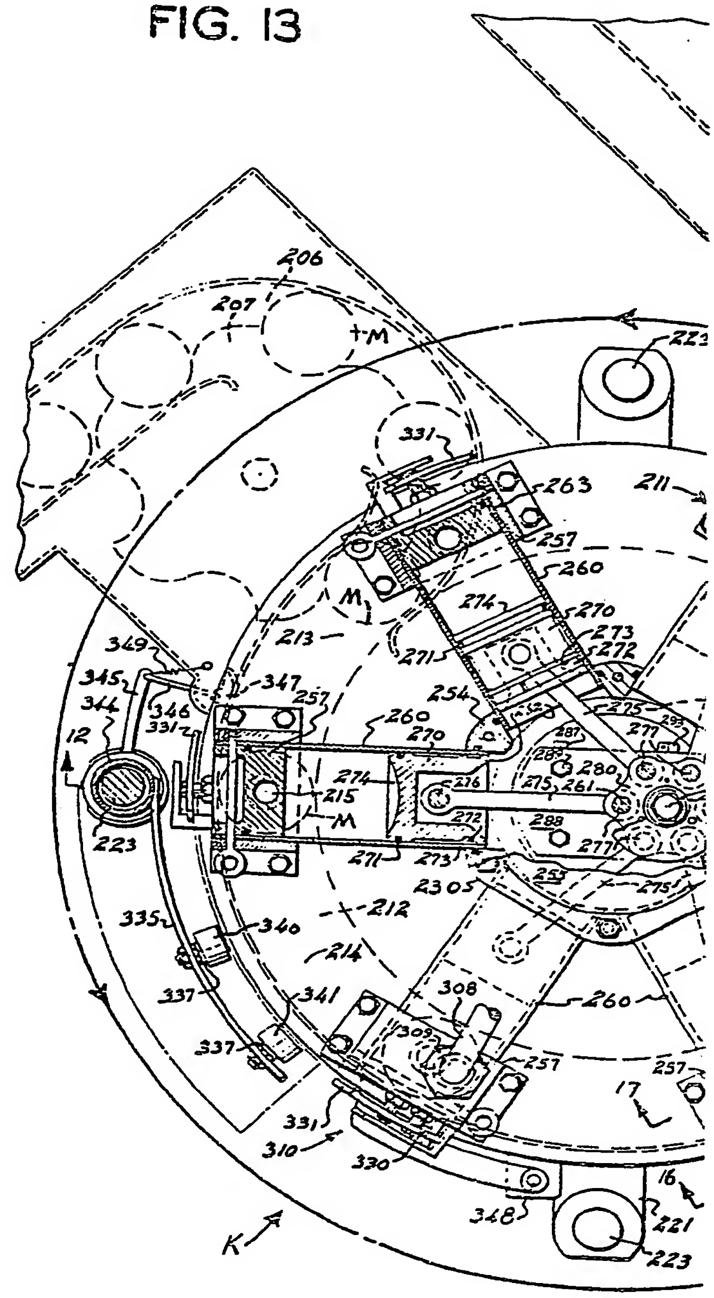
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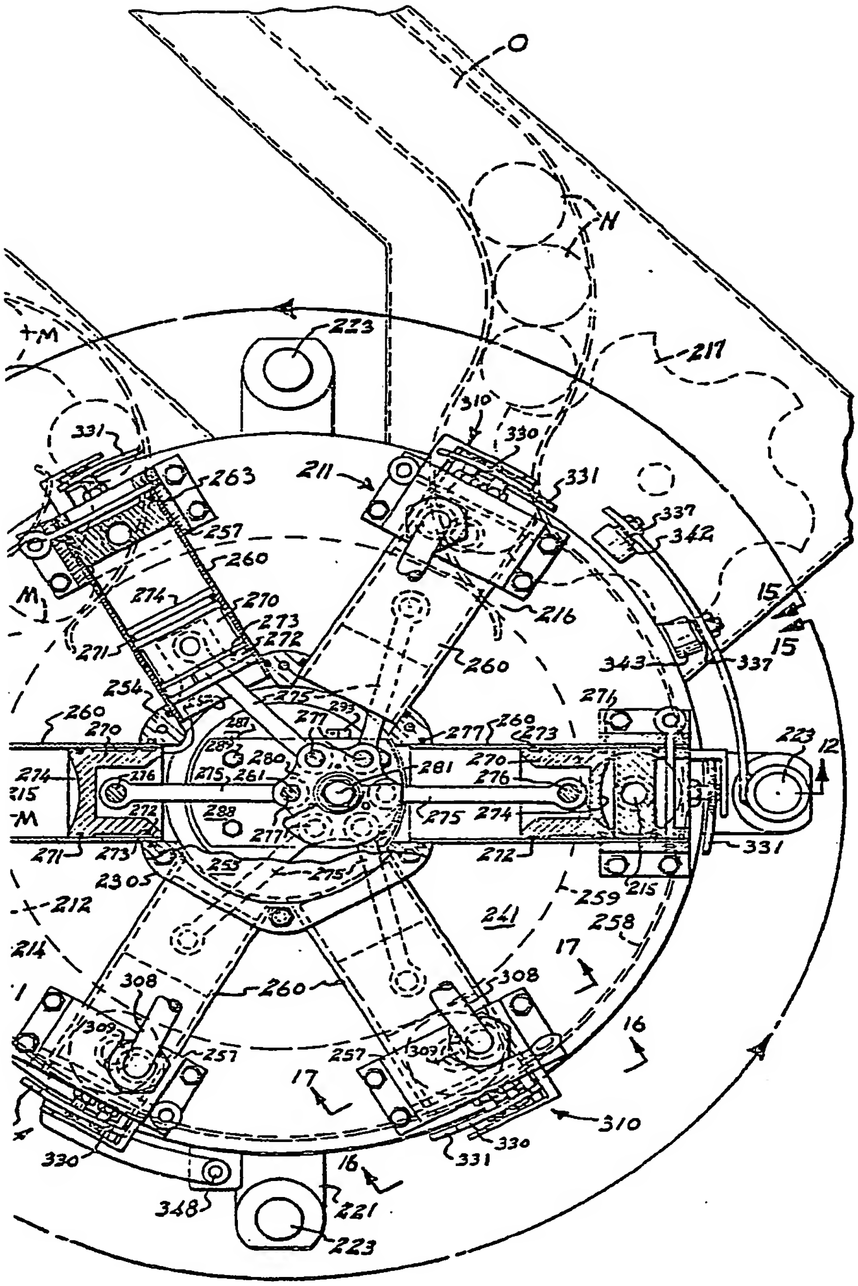
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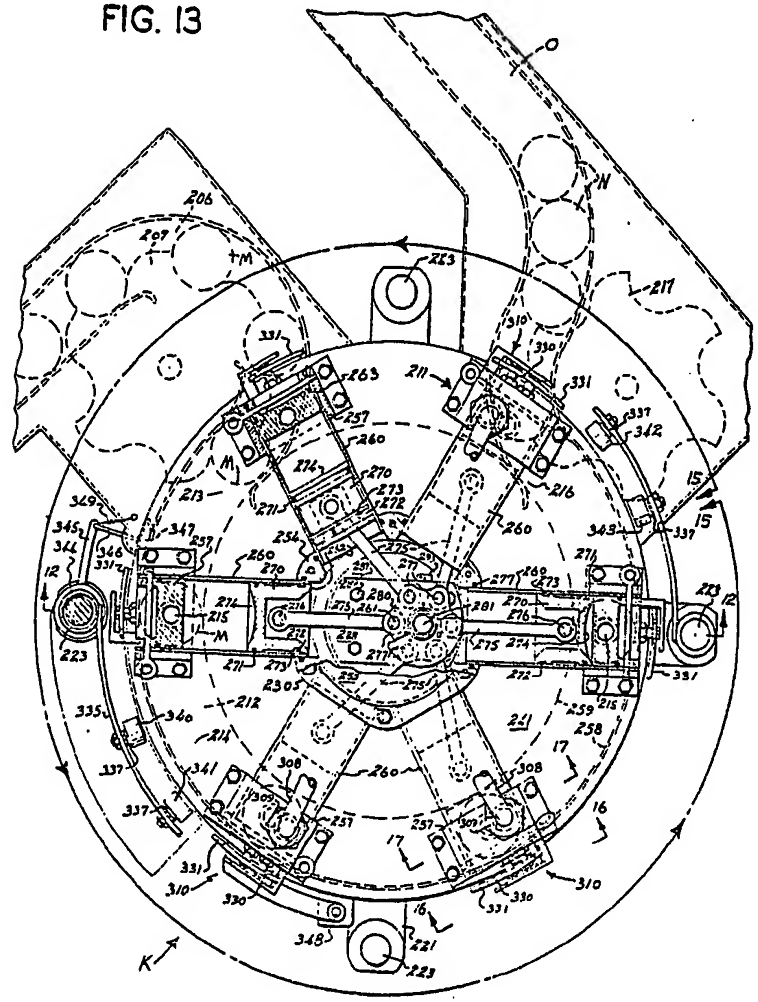
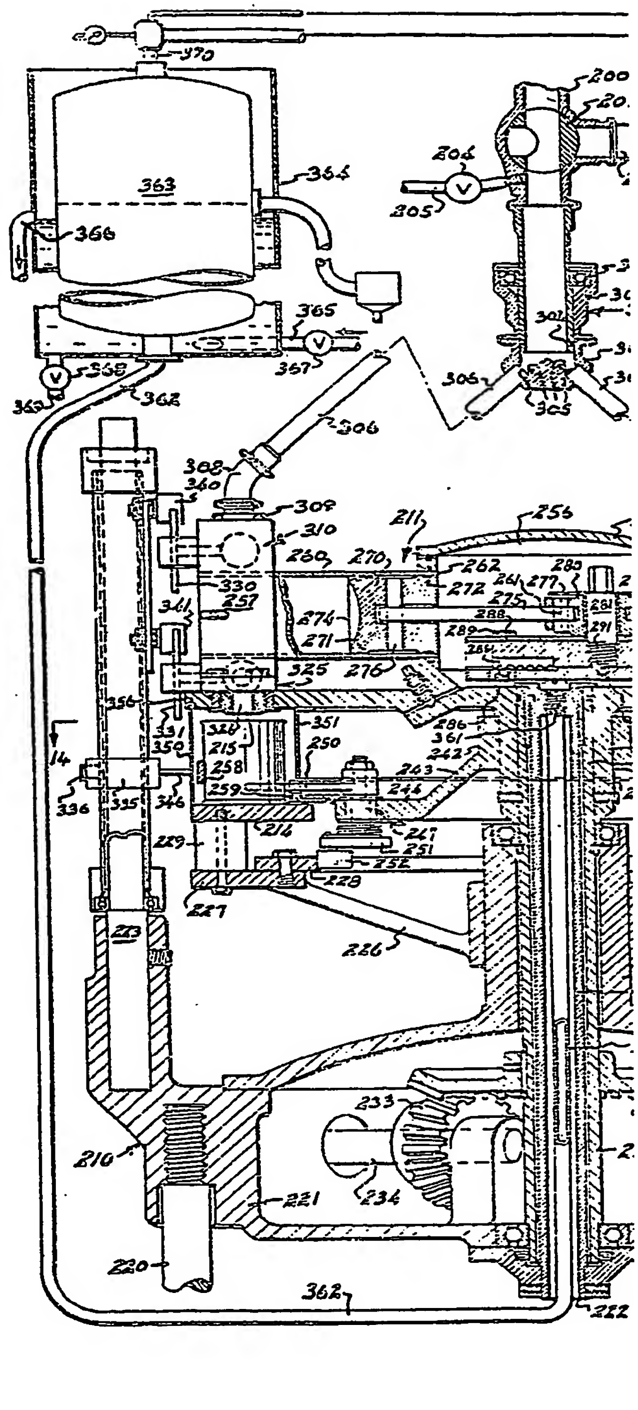
FIG. 13

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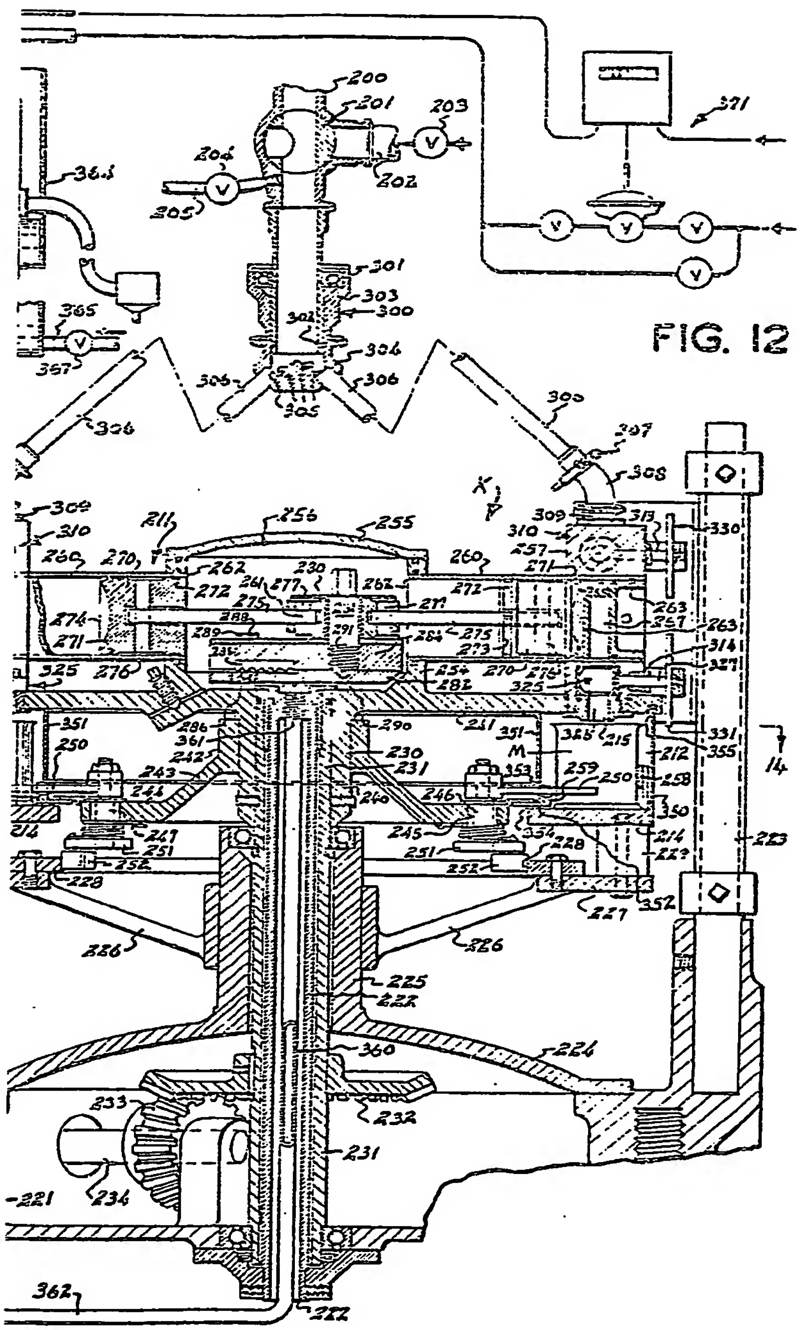

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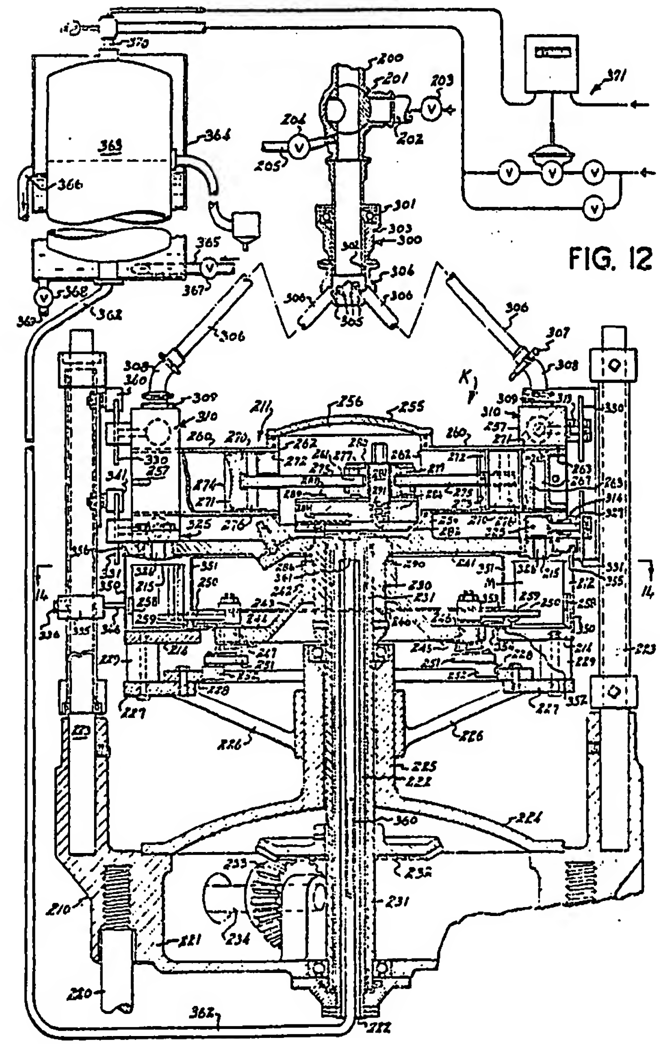
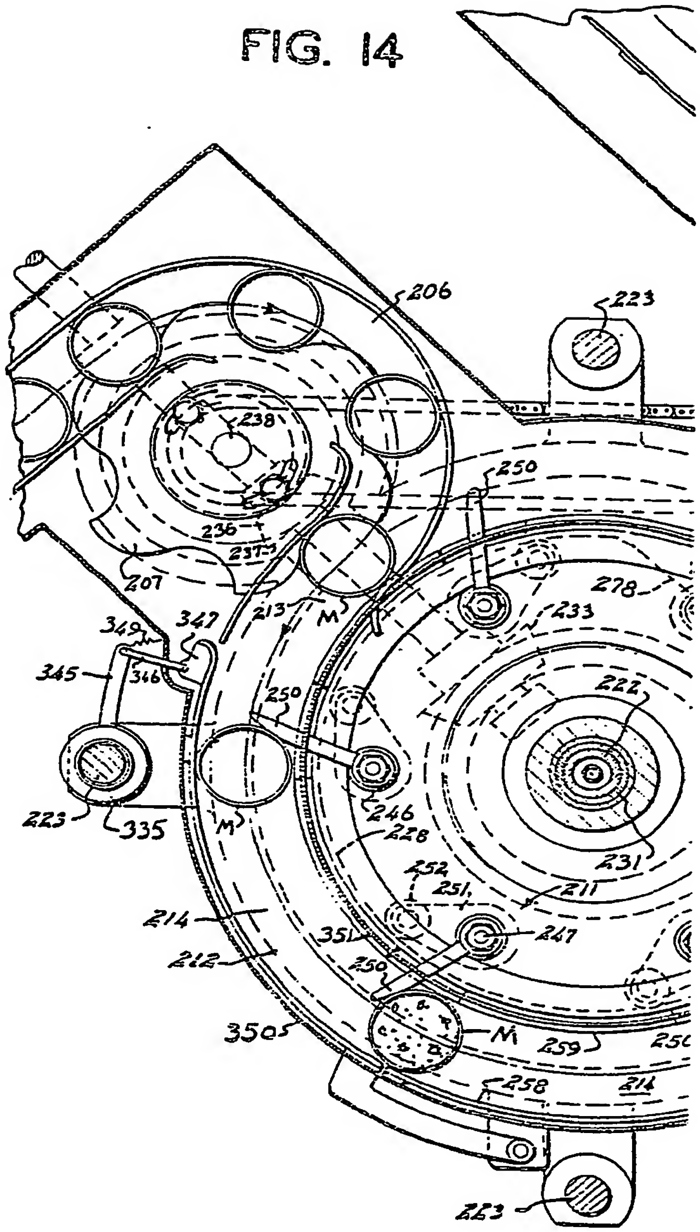


FIG. 12

FIG. 14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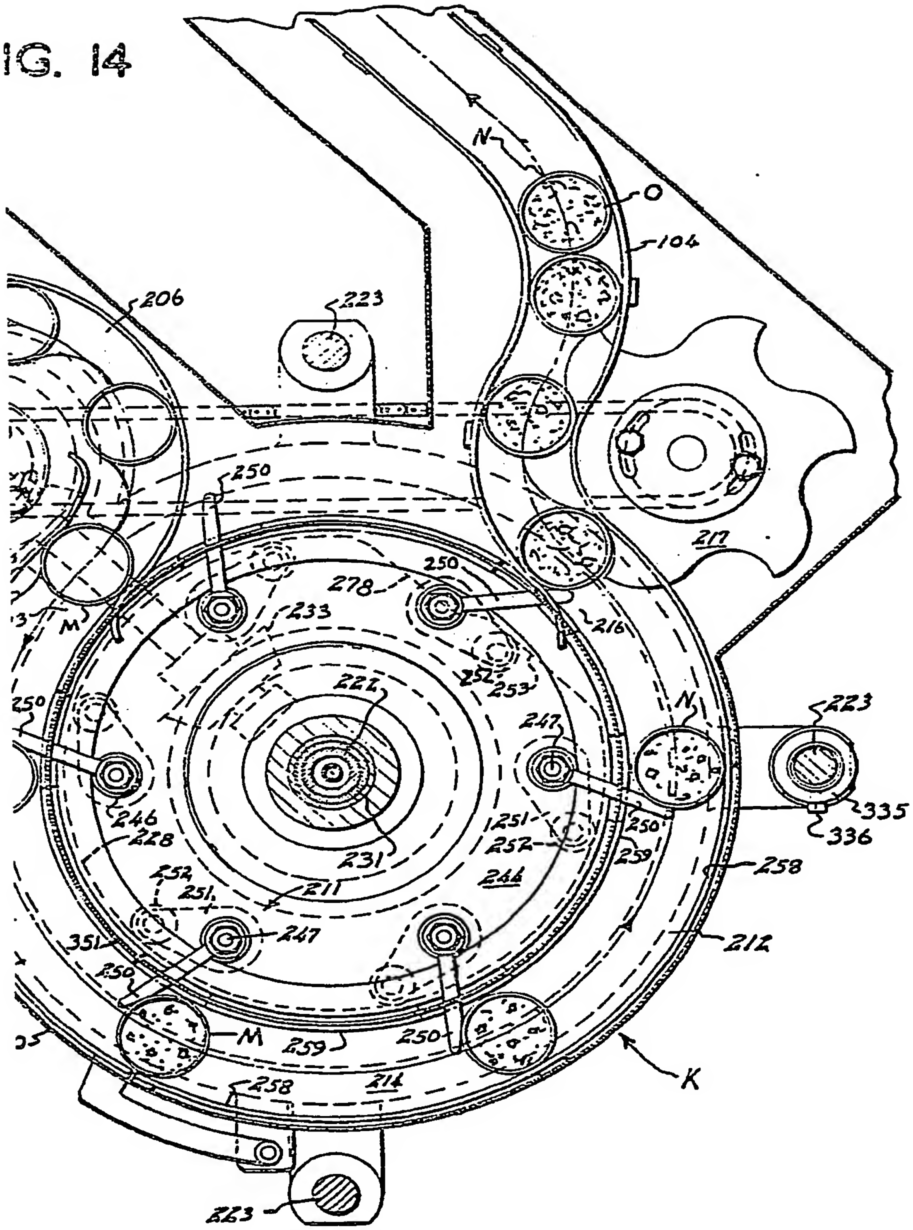
Sheet 10

IG. 14



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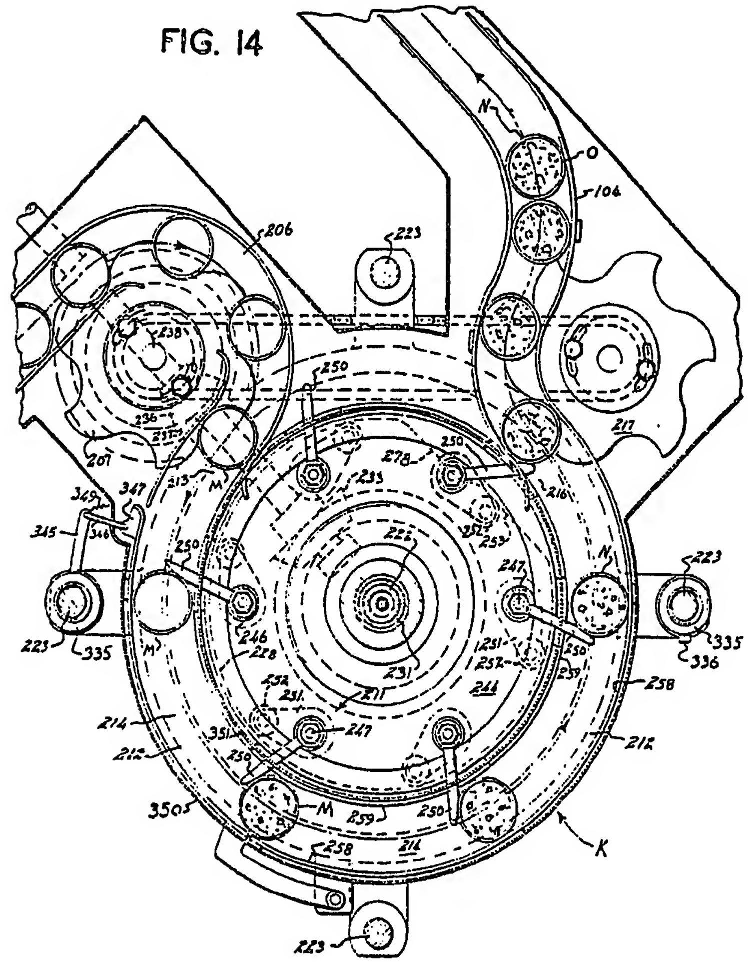
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